

## INK JET PRINTING METHOD AND APPARATUS

### FIELD OF THE INVENTION AND RELATED ART

5 The present invention relates to an ink jet printing apparatus which forms letters and pictures by means of ejecting ink droplets onto print medium.

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10 The present invention also relates to an ink jet printing method. According to this method, dye containing color ink is ejected on the print medium so as to mix or react with colorless or light colored liquid (print quality improver liquid) which contains various compounds capable of rendering the dye in the ink insoluble, producing thereby a highly reliable print with improved water resistance, light  
15 resistance, or the like properties, or a high density image of high quality, which suffers little from feathering or color bleeding.

Further, the present invention relates to a color ink jet printing method for printing color  
20 images, clearly and with high density. More specifically, it relates to a printing method in which a set of color inks, such as yellow (Y), magenta (M) and cyan (C), or green (G), red (R) and blue (B), is used in combination with black (Bk) ink.

25 The present invention is applicable to all of the apparatuses which use print medium such as paper, fabric, leather, unwoven fabric, or the like, as well

as metals. As for specific examples of such apparatuses, it is possible to list office equipment or industrial production equipment such as printers, copying machines, or facsimiles.

5           The printing method based on the ink jet system is widely used in printers, copying machines, facsimiles, and the like since it is advantageous in that the operating noise is low; the running cost is low; its size can be easily reduced; or it can be  
10 easily converted to print color images.

          However, in order to produce "highly reliable printed products," or "printed images of high quality," using the conventional ink jet printing method, it was necessary to use specific paper  
15 suitable for the purpose; in other words, it was necessary to use dedicated paper with an ink absorbing layer. In recent years, a method has been put to practical use, which accomplishes the these objectives by means of improving the ink so that the desirable  
20 results can be obtained using "plain' paper used in large quantity in the printer or copying machines. However, the level of quality reachable using this method has been unsatisfactory.

          As for the method in which the ink is  
25 modified to improve the water resistance of the image, a method has been known, in which the water resistance is given to the coloring material contained in the

ink. Basically, the ink used in this method is rendered difficult to re-dissolve in the water once the ink dries; therefore, it is liable to plug the nozzles of the printing head, and also, the

5 performances of the plugged nozzles are difficult to restore. Of course, these problems can be prevented, but the prevention requires a complicate structure.

A Japanese Laid-Open Patent Application No. 84,992/1981 discloses a method, in which the print  
10 medium is coated in advance with a material capable of fixing the dye to the print medium. This method, however, requires the use of specific print medium, and also, cannot avoid increases in the size and cost of the apparatus, since the material for fixing the  
15 dye has to be coated. Further, it is rather difficult to coat reliably the dye fixing material to a predetermined thickness.

Also, a Japanese Laid-Open Patent Application No. 63,185/1989 discloses a technology for adhering to  
20 the print medium a type of colorless ink capable of rendering the dye insoluble, using an ink jet printing head. In this method, the dot diameter of the colorless ink is rendered larger than that of the dot diameter of the printing ink; therefore, even when the  
25 landing points of the printing inks and colorless ink are displaced from each other, the satisfactory print or image quality can be obtained.

However, this method also suffers from the following shortcoming. In other words, this method injects the colorless ink across the entire surface where the images are to be formed; therefore, a large  
5 amount of the colorless ink is consumed, and as a result, the running cost increases. Also, since more than usual amount of ink is injected into the print medium, it takes a longer time to dry the ink, and also, the landing points of the inks are displaced  
10 from each other because of the cockling of the print medium, which occurs as the ink adhered to the print medium dries. In particular, when a color image is formed, the cockling, which leads to the misalignment of the landing points, greatly deteriorates the image  
15 quality. The patent application being discussed here does not disclose any method for optimizing the amount of the colorless ink to be adhered to the print medium, according to the type of the print medium. Further, the colorless ink is ejected even when the  
20 high quality is not required, for example, even when the recording is made in a draft mode; therefore, the colorless ink is wastefully consumed. Further, the liquid permeation into the print medium varies depending on the environmental factors such as ambient  
25 temperature or humidity; therefore, there are times when the dye insolubilizing colorless ink fails to mix or react idealistically with the image producing ink,

and as a result, the dye is not insolubilized.

Also, the liquid differently permeates the print medium depending on the type of the print medium; therefore, there are times when the dye  
5 insolubilizing color less ink fails to mix or react idealistically with the image producing ink, and as a result, the dye is not insolubilized.

Therefore, this method suffers from another shortcoming. Namely, when the dye is not  
10 insolubilized, the feathering or bleeding occurs to degrades the print image. Here, "feathering" means a phenomenon that the bleeding ink leaves on the print medium, a pattern of trails that looks like a feather, and "bleeding" means a phenomenon that the color inks  
15 mix with each other on the print medium after they are deposited thereon.

There have been disclosed a large number of conventional technologies which are intended to improve the fastness of the print. A Japanese Laid-  
20 Open Patent Application No. 24,486/1978 discloses a technology which improves the resistance of the dyed product against humidity. According to this technology, the dyed product is put through a process in which the dye in the dyed product is turned into  
25 lake so that it is firmly fixed.

A Japanese Laid-Open Patent Application No. 43,733/1979 discloses a printing method, in which an

ink jet printing system is used in conjunction with two or more ink components which increase their film forming capacities as they make contact with each other under the normal or heated condition; wherein  
5 those components are allowed to make contact with each other on the print medium so that a film capable of adhering firmly to the print medium is formed.

A Japanese Laid-Open Patent Application No. 150,396/1980 also discloses a method in which an agent  
10 capable of forming the lake with the water soluble dye in a water based ink is applied after the ink jet printing.

In a Japanese Laid-Open Patent Application 128,862/1983, an ink jet printing method is disclosed,  
15 in which it is anticipated where the image producing ink is deposited, and the image producing ink and the processing ink are deposited thereon in a overlapping manner. According to this method, the processing ink may be deposited before the image producing ink, or  
20 may be overlaid on the image producing ink deposited before the processing ink; or the image producing ink may be overlaid on the processing ink deposited before the image producing ink, and thus deposited image producing ink may be covered with the processing ink.

25 However, the problems that might have occurred through the practical applications of these printing methods have not been disclosed in these

journals which present these prior technologies.

Further, no method has been disclosed in these patent applications, in which when two or more inks of different color are used, the processing liquid (print quality improver liquid) is made to react with only the ink of a specific color, nor has been disclosed a method in which a recording mode suitable for a specific purpose can be selected from among a number of available recording modes.

Also, no method has been disclosed, which can minimize the amount of the processing liquid to be applied to the area which basically has no bearing on the printing results.

SUMMARY OF THE INVENTION

The present invention was made in consideration of the aforementioned problems, and its object is to obtain a "reliable print," which displays better water resistance and light resistance, and faster fixation than those of the conventional print, even when plain paper is used as the print medium.

Another object of the present invention is to provide an ink jet printing method and a printing apparatus, which are capable of producing a "high quality printed image" which has high density and highly developed colors, and does not suffer from the feathering or color bleeding.

Another object of the present invention is to provide an ink jet printing method and a printing method, which are capable of depositing efficiently the print quality improver liquid on the print medium, without wastefully consuming the print quality improver liquid.

Another object of the present invention is to provide a printing method in which an optimal process is carried out depending on the print medium type, for example, whether the print medium is the OHP transparency or something else, so that a high quality image with the highest water resistance can be obtained.

A further object of the present invention is to provide a printing method in which the amount of the processing liquid to be ejected is minimized to reduce the running cost, while producing a high quality image having a minimum amount of cockling.

Another object of the present invention is to improve the fastness of the ink fixation to the print medium, the water resistance of the produced image, and the color development of the produced image, and to minimized the color bleeding among two or more color inks, by means of causing the print quality improver liquid to mix or react with the ink, on the print medium.

In other words, the ink jet printing method



in accordance with the present invention is such an ink printing method that coloring material containing color ink, and colorless or lightly colored liquid (hereinafter, print quality improver liquid, or P liquid) containing components capable of rendering the ink components insoluble or aggregating them, are ejected onto the print medium, where the ink mixes and/or reacts with the P liquid to produce a highly reliable image of high quality.

10           The data to be used for ejecting the P liquid are derived from the data to be used for ejecting the color inks: yellow (Y), magenta (M), cyan (C) and black (Bk) inks.

15           Further, this printing method provides two or more printing modes, and the amount, type, or the like, of the P liquid to be ejected, is determined according to the selected mode. In this case, the data for ejecting the P liquid may be differently composed depending on whether the Bk ink or the Y, M and C inks are ejected, and also, printing timing may set up so as to provide a lag between the P liquid, and Bk, Y, M and C inks.

25           In the present invention, the terminology, "print quality improvement," includes: the improvement in image properties such as the density, saturation, sharpness of edge, dot diameter, or the like; the improvement in the fixability of the ink; the

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improvement in the durability related properties of the image, such as the weather resistance, water resistance, light resistance, or the like; and the suppression of the bleeding, feathering, and the like.

5 The print quality improver liquid is liquid contributory to the improvement of the print properties, and includes liquid capable of insolubilizing the dye contained in the ink, liquid capable of disturbing the state of pigment dispersion  
10 in the ink, as well as the like liquid. Here, the terminology, "insolubilize," refers to a phenomenon that anionic radicals in the ink dye, and cationic radicals in the cationic substance contained in the print quality improver liquid, ionically react with  
15 each other, being thereby ionically bonded, and as a result, the dye in the state of being uniformly dissolved in the ink separates from the ink solution. It should be noted here that even when the dye in the ink is not entirely rendered insoluble, the present  
20 invention can effectively suppress the bleeding, and improve the color development, letter quality, fixibility of the ink, and the like. Further, when the coloring material used in the ink is the water soluble dye containing anionic radicals, the  
25 terminology, "aggregate," is used as a terminology having the same meaning as "insolubilize," but when the coloring material in the ink is pigment, it also

means the phenomenon that the pigment dispersant or the pigment surface ionically interacts with the cationic radicals of the cationic substance contained in the print quality improver liquid, and as a result, 5 the state of the pigment dispersion is disturbed, which results in the increase in the pigment diameter. Normally, as the aggregation progresses, ink viscosity increases. It should be also noted that even when the pigment or pigment dispersant in the ink is not 10 entirely aggregated, the present invention can effectively suppress the bleeding, and improve the color development, letter quality, fixability of the ink, and the like.

In the present invention, the P liquid can be 15 optimally used according to the selected printing mode; therefore, the power source capacity of the printing apparatus can be reduced, which makes it possible to reduce the apparatus size, as well as its cost.

20 The present invention relates to an ink jet printing method, which, in order to accomplish the aforementioned objectives, uses the print quality improver liquid, which is mixed or caused to react with the colored inks: Y, M, C and Bk inks, on the 25 print medium, in response to the imaging data. The type and amount of the print quality improver liquid are optimally selected depending on the environmental

factors such as the ambient temperature and humidity,  
and/or the type of the print medium; therefore, it is  
possible to obtain always a "highly reliable" image  
with "high quality" regardless of the environment  
5 and/or the type of the print medium.

In the present invention, the "adjustment" of  
the amount of the print quality improver liquid  
includes selecting "non-ejection" of the print quality  
improver liquid, as well as determining the amount of  
10 the P liquid to be ejected per unit area of the print  
medium.

According to the present invention, when the  
print quality improver liquid and the inks are mixed  
on the print medium, the higher the ambient  
15 temperature is, and the lower the humidity is, the  
less the print quality improver liquid is used.

The reasons why such a control that uses a  
less amount of the print quality improver liquid as  
the ambient temperature becomes higher, and the  
20 humidity becomes lower is effective are as follows:

(1) The higher the temperature is, a shorter time  
it takes for the print quality improver liquid and the  
color inks to mix or react with each other, and more  
efficiently they do so, while they permeate from the  
25 surface of the print medium thereinto; therefore, the  
necessary amount of the print quality improver liquid  
to be mixed or caused to react with the inks may be

less.

(2) The lower the humidity is, the more difficult it is for the ink to permeate into the print medium. Therefore, the time necessary for these liquids to permeate into the print medium from the surface thereof becomes longer, affording thereby enough time for the print quality improver liquid to mix or react satisfactorily with the colored inks.

An excessive amount of the print quality improver liquid produces contrary results; it induces the feathering of the colored inks. Further, the print quality improver liquid is replenished from the container therefor as it is consumed. Therefore, minimizing the print quality improver liquid usage can also reduce the running cost.

The temperature based control of the Tw of the print quality improver liquid and the humidity based control of the Tw of the print quality improver liquid may be independently executed. Though detection of the humidity alone may be effective in some degree, the best results can be obtained when the control is executed on the basis of both the temperature and humidity.

In the following embodiments of the present invention, a case in which the Tw is controlled in order to control the amount of the print quality improver liquid to be ejected is described, but the

present invention is not limited by this case. For example, when the amount of the print quality improver liquid is increased by means of controlling the temperature of the print quality improver liquid head unit, the temperature may be increased in order to increase the amount of the print quality improver liquid. Other means may be employed.

Further, when the print quality improver liquid is selectively used on the basis of the user's objective, and/or the characteristic of the printing ink to be used, it is possible to produce a "highly reliable" printed product with improved water resistance and light resistance, and the like, and a printed image of "high quality" which displays preferable color development and high density while suffering little from the feathering and color bleeding.

According to an aspect of the present invention, the print quality improver liquid and inks are caused to mix or react with each other on the print medium, so that the water resistance and color development of the printed image are improved; color bleeding among two or more color inks is minimized; and the fixability of the ink to the print medium is improved.

According to another aspect of the present invention, three modes are available, which are

manually or automatically switchable, page by page,  
and/or in the middle of each page. In other words,  
the printing mode is discriminated with reference to  
the printing area so that the print quality improver  
5 liquid can be properly applied. Therefore, it is  
possible to minimize the amount of the print quality  
improver liquid consumed during the printing, without  
losing the effectiveness of the liquid.

According to another aspect of the present  
10 invention, the liquids (including the inks) are  
ejected in the following order: non-black ink print  
quality improver liquid black ink. Using this order  
can assure the effects of the print quality improver  
liquid. This is because of the following reason; when  
15 the liquids are ejected in a different order, for  
example, non-black ink black ink print quality  
improver liquid, the print quality improver liquid is  
going to be ejected after bleeding occurs between the  
non-black ink and black ink.

20 According to another aspect of the present  
invention, the amount of the image producing ink to be  
ejected onto the area where it is overlaid on the  
print quality improver liquid is increased relative to  
where it is not overlaid. This is because the  
25 reaction between the print quality improver liquid and  
ink stops the permeation of the ink at the location of  
the reaction, resulting thereby in a smaller dot

diameter.

These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention, taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of an embodiment of the ink jet printing apparatus in accordance with the present invention.

Figure 2 is a front view of a printing head unit of the printing apparatus illustrated in Figure 1, wherein the unit comprises a plurality of subunits.

Figure 3 is an enlarged sectional view of the print head illustrated in Figure 2.

Figure 4 is a block diagram of the structure of the embodiment of the ink jet printing apparatus in accordance with the present invention.

Figure 5 is a flow chart of the printing operation of the first embodiment of the ink jet printing method in accordance with the present invention.

Figure 6 is a planar drawing illustrating how the printing head unit moves when the single pass printing method is employed while the ink jet printing



method in accordance with the present invention is practiced.

Figure 7 is a planar drawing illustrating how the printing head moves when the double pass printing method is employed while the ink jet printing method in accordance with the present invention is practiced.

Figure 8 is an enlarged sectional view of the printing head used in the second embodiment of the ink jet printing method in accordance with the present invention.

Figure 9 is a flow chart of the printing operation in the second embodiment of the ink jet printing method in accordance with the present invention.

Figure 10 is a flow chart of the printing operation for the third embodiment of the ink jet printing method in accordance with the present invention.

Figure 11 is a flow chart of the printing operation in the fourth embodiment of the ink jet printing method in accordance with the present invention.

Figure 12 is another flow chart of the printing operation in the fourth embodiment of the ink jet printing method in accordance with the present invention.

Figure 13 is a front view of the printing

head unit used in the fifth embodiment of the ink jet printing method in accordance with the present invention.

Figure 14 is a chart presenting the printing data to be used for ejecting the Y, M, C and Bk inks, and the P liquid, in the first embodiment of the ink jet printing method in accordance with the present invention.

Figure 15 is a block diagram illustrating the general structure which will be employed when the printing apparatus in accordance with the present invention is applied to an information processing apparatus capable of functioning as a word processor, a personal computer, a facsimile, copying machine, or the like.

Figure 16 is a schematic external view of the information processing apparatus illustrated in Figure 15.

Figure 17 is a schematic external view of another example of the information processing apparatus comprising the printing apparatus in accordance with the present invention.

Figure 18 is a general perspective view of the printing section in an embodiment of the ink jet recording apparatus in accordance with the present invention.

Figure 19 is a general perspective view of

the carriage of the printing section illustrated in Figure 18.

Figure 20 is an enlarged, exploded perspective view of the carriage illustrated in Figure 19.

Figure 21 is a general perspective view of a recording head mountable on the carriage illustrated in Figure 20, and an ink container mountable replaceably on this recording head.

Figure 22 is an exploded perspective view of a fixing member for connecting electrically the contact portion of the recording head and the main assembly of the printing apparatus.

Figure 23 is an exploded perspective view of the carriage of the printing section, and a means for detecting the position thereof.

Figure 24 is a general perspective view of the structure for fixing the positional relationship between the carriage of the printing section, and the head base of the recording head portion.

Figure 25 is a side view of a fixing means for assuring the reliability of the positional relationship fixing structure illustrated in Figure 24.

Figure 26 is a sectional view of the fixing member for connecting electrically the contact portion of the recording head portion and the apparatus main

assembly.

Figure 27 is a sectional view of an FPC holder and the recording head portion, illustrating how the two are engaged.

5           Figure 28 is a sectional side view of the recording head portion and ink container portion, which are on the carriage portion.

10           Figure 29 is a perspective external view of an embodiment of the ink jet recording apparatus in accordance with the present invention.

Figure 30 is an explanatory block diagram of the control system in an embodiment of the ink jet recording apparatus in accordance with the present invention.

15           Figure 31 is a perspective drawing depicting the structure of an embodiment of the ink jet printing apparatus in accordance with the present invention.

20           Figure 32 illustrates the structure of a liquid ejecting portion, wherein (a) is a perspective view of the head units of the liquid ejecting portion disposed on the carriage; (b) is a front view, as seen from the direction of the print medium, depicting the arrangement of the ejection outlets in the liquid ejecting portion; and (c) is an enlarged sectional  
25           view depicting the internal structure of the ejection outlet illustrated in (c).

Figure 33 is a data table showing the data to

be used for ejecting the print quality improver liquid using the ink liquid ejecting portion illustrated in Figure 32.

Figure 34 is a flow chart of an embodiment of the ink jet printing method in accordance with the present invention.

Figure 35 is a graph to show the relationship between the internal temperature of the ink jet printing apparatus and the  $T_w$ .

Figure 36 is a flow chart of another embodiment of the ink jet printing method in accordance with the present invention.

Figure 37 is a graph to show the relationship between the temperature and  $T_w$ .

Figure 38 is a front view of an example of the liquid ejecting portion employed in an embodiment of the ink jet printing method in accordance with the present invention.

Figure 39 is a front view of an example of the liquid ejecting portion employed in another embodiment of the ink jet printing method in accordance with the present invention.

Figure 40 is a flow chart of an operation for applying the print quality improver liquid to the Bk ink only.

Figure 41 is a planar drawing of a printed product obtained through the application of another

embodiment of the ink jet printing method in accordance with the present invention.

Figure 42 is a flow chart of an operation for applying the print quality improver liquid to the letters only.

Figure 43 is a flow chart of an operation for applying the print quality improver liquid to the Bk ink letters only.

Figure 44 is a flow chart of an operation for applying the print quality improver liquid to the C, M and Y inks only.

Figure 45 is a front view of another example of the ink liquid ejecting portion employed in an embodiment of the ink jet printing method in accordance with the present invention.

Figure 46 is a front view of another example of the ink liquid ejecting portion employed in an embodiment of the ink jet printing method in accordance with the present invention.

Figure 47 is a front view of an example of the ink liquid ejecting portion, which is employed in an embodiment of the ink jet printing method in accordance with the present invention, and is capable of ejecting two types of print quality improver liquid.

Figure 48 is a block diagram of an ink jet printing apparatus to which the present invention is

applicable.

Figure 49 is a perspective view of a recording apparatus to which the present invention is applicable.

5           Figure 50 is a perspective view of a recording head unit.

Figure 51 is an explanatory drawing of the recording head structure.

10           Figure 52 is a flow chart of a recording operation in accordance with the present invention.

Figure 53 is an explanatory drawing of the various subheads in the heads to be used in the mode b.

15           Figure 54 is an enlarged sectional view of a different recording head.

Figure 55 is a flow chart of another recording operation in accordance with the present invention.

20   DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the embodiments of the present invention will be described with reference to the drawings. First, referring to Figures 1 - 17, the embodiments 1 - 5, which represent the first form the present invention, will be described.

Embodiment 1

Figure 1 is a perspective view of an ink jet

printing apparatus, to which the present invention is applicable. After being inserted into the feeding point of a printing apparatus 100, a print medium 106 is conveyed by a feeder roller 109 to an area in which  
5 a printing head unit 103 can print images on the print medium 106. The printing head unit 103 is constituted of a Bk ink liquid ejecting portion, a Y ink liquid ejecting portion, an M ink liquid ejecting portion, a C ink liquid ejecting portion, and a P liquid ejecting  
10 portion. The liquid ejecting portion in this embodiment may be a part of the printing head unit, or may constitutes a printing head independent from each other.

There is a metallic platen 108 below the  
15 print medium having been conveyed to be disposed within the printing area. A carriage 101 is reciprocally movable in the direction defined by two guide shafts 105 and 106, and as it is moved, it scan the printing area. On the carriage 101, the printing  
20 head unit 10 is mounted, which comprises four ink containers for supplying four color inks, and four printing heads for ejecting the inks. The four color inks supplied to the ink jet printing apparatus in this embodiment are black (Bk), cyan (C), Magenta (M)  
25 and Yellow (Y) inks. A reference numeral 107 designates a panel comprising a group of switches and a group of displays. The panel 107 is used to set



various printing modes, or display the status of the printing apparatus.

Figure 2 is a front view of the printing head subunits of the printing head unit 103. There are 5 ejection outlets on the ejection outlet surface of the printing head. The number of the ejection outlets corresponds to the number of liquids: P, Bk, C, M and Y. The number of the ejection outlets assigned to each liquid is 64. The 64 ejection outlets assigned 10 to each liquid are linearly aligned with the intervals of approximately 70  $\mu\text{m}$ , that is, with a density of 360 dpi. Further, the ejection outlets are arranged in such a manner that an image is printed in the color order of the P, Bk, C, M and Y.

15 The ink jet printing apparatus of this embodiment employs a printing system, in which an electrothermal transducer is disposed in correspondence with the ejection outlet, wherein a driving signal reflecting printing data is applied to 20 the electrothermal transducer to eject the ink from a nozzle.

Figure 3 is an enlarged sectional view of a printing head, to which the present invention is applicable. A heat generating member 30, which is the 25 electrothermal transducer of the printing head 102 is disposed in correspondence with the ejection outlet 23, one for one, and each of the heat generating

member 30 is allowed to generate heat independently. As the heating member 30 generates the heat, the ink adjacent to the heat generating member 30 is suddenly heated, being brought into the state of the film boiling, generating thereby bubbles. The pressure from the development and growth of the bubbles forces an ink droplet 35 to be ejected toward a print medium 31, effecting thereby a letter or a picture image on the print medium. The volume of the color ink droplet ejected at this time falls within a range of 15 - 80 ng: for example, approximately 40 ng.

Each of the ejection outlets 23 is connected to an ink liquid passage, and behind the area in which the ink liquid passages is placed, a common liquid chamber 32 is provided, from which the ink is supplied to these ink liquid passage. In each ink liquid passage, which corresponds to one of the ejection outlets, the heat generating member 30, that is, the electrothermal transducer, and electrode wiring for supplying the electric power to the heat generating member 30, are disposed, wherein the former generates the energy to be used for ejecting the ink droplet from the ejection outlet. The heat generating member 30 and electrode wiring are formed on a substrate 33 composed of silicon or the like, using one of the film deposition technologies. On the heat generating member 30, a protective film 36 is formed so as to

prevent a direct contact between the ink and heat  
generating member 30. Further, a partitioning wall 34  
composed of resin or glass is accumulated on the  
substrate 33 to form the aforementioned ejection  
5 outlets, ink liquid passages, common liquid chamber,  
and the like.

In the case of the printing method such as  
the one described above, in which the electrothermal  
transducer is employed, the bubble formed through the  
10 application of thermal energy is used to eject the ink  
droplet; therefore, it is commonly called "bubble jet  
printing system."

Figure 4 is a block diagram of the ink jet  
printing apparatus to which the present invention is  
15 applicable. The data (hereinafter, image data) for  
the letter and/or image to be printed are inputted  
from a host computer to the receiving buffer 401 of  
the printing apparatus. The data for confirming  
whether or not the image data are correctly  
20 transferred, and the data for displaying the  
operational condition of the printing apparatus, are  
returned from the printing apparatus to the host  
computer. The data from the receiving buffer 401 are  
transferred, under the control from a CPU 402, to a  
25 memory section 403, where it is temporarily stored in  
an RAM (random access memory). A mechanism  
controlling section 404 drives a mechanical section

405 comprising a carriage motor, a line feeder motor,  
or the like, in response to the commands from the CPU  
403. A sensor/SW controlling section 406 sends the  
signal from the sensor/SW section 407 comprising  
5 various sensors and SWs (switches), to the CPU 402. A  
display element controlling section 408 controls a  
display element section comprising display elements  
such as an LED or the like in the group of display  
panels, in response to the command from the CPU. A  
10 printing head controlling section 410 controls a  
printing head 411 also in response to the command from  
the CPU, and also, it senses the temperature and the  
like, which indicates the condition of the print head  
411, and sends them to the CPU.

15           Figure 5 is a flow chart of the printing  
operation in Embodiment 1.

          In Step 11, a printing mode is determined.  
This determination is dependent on the data from the  
host computer connected to the printing apparatus, or  
20 the selection made using a switch or switches among  
the group of switches. Upon the determination of the  
printing mode, one of Steps 11, 12 and 13 is taken.

          The Step 12 initiates a printing mode, in  
which the P liquid is not used. Even through the use  
25 of the P liquid makes up the gist of the present  
invention, the mode that does not involve the P liquid  
is provided as one of the printing modes. For

example, this mode is used as a mode for trial printing; the P liquid is not used in trial printing so that the running cost is reduced.

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The Step 13 initiates a printing mode, in  
5 which the P liquid is used while a monodirectional single pass printing is carried out. Figure 6 is a drawing for describing the specific movement of the printing head unit during this monodirectional single pass printing operation; it illustrates how the  
10 printing head unit 103 moves over the print medium 106, which is an A4 size plain paper. The liquid on the far right side in the printing head unit is the P liquid. Printing is carried out in the direction of an arrow mark A, and the printing head unit 103 is  
15 simply returned in the direction of an arrow mark B. The numbers on the right-hand side of the drawing indicate the number of the scanning passes that the printing head unit 103 has made during the current printing operation. The drawing shows the printing  
20 head unit 103 during its fourth scanning pass.

Step 14 initiates a printing mode, in which an image is effected through a monodirectional double pass printing method while using the P liquid. Figure 7 illustrates the specific movement of the printing  
25 head unit 103 during this monodirectional double pass printing operation; it illustrates how the printing head unit 103 moves over the print medium 106, which

is an A4 size plain paper. The liquid on the far right side in the printing head unit is the P liquid. Printing is carried out in the direction of an arrow mark A, and the printing head unit 103 is simply  
5 returned in the direction of an arrow mark B. The numbers on the right-hand side of the drawing indicate the numbers of the scanning passes the printing head unit 103 has made during the current printing operation. The drawing shows the printing head unit  
10 103 during its fourth scanning pass.

In Step 15, the P liquid amount suitable for the single pass printing mode initiated in Step 13 is established. In the single pass printing mode, all the colors are printed during a single scanning pass.  
15 In this mode, a relatively large amount is set for the P liquid. This is because in the case of the single pass printing operation, a relatively large amount of color inks is ejected per unit time and unit area of the print medium, and therefore, the amount of the P  
20 liquid also has to be increased to enhance the reaction between the color inks and P liquid. The printing (ejection) data for the P liquid are derived from the printing data for the Y, M, C and Bk inks. More specifically, the data for the P liquid are the  
25 logical sums of the printing data for the Y, M, C and Bk inks. In this embodiment, the amount of the P liquid to be ejected is established to be 30 ng.

In Step 16, the amount suitable for the double pass printing mode initiated in Step 14 is established for the P liquid. In the double pass printing mode, two scanning passes are used to print all the color, and a relatively small amount is set for the P liquid. This is because in the case of the double pass printing operation, a relatively small amount of the color inks is ejected per unit time and unit area of the print medium, and therefore, the color inks sufficiently react with the P liquid even if the amount of the P liquid is reduced. In this embodiment, the amount of the P liquid is set at 20 ng.

It is one of the roles of the printing head controlling section 410 to control the amount of the ink ejected from the same printing head. For example, it controls the energy to be given for ejecting a single ink droplet, which is accomplished by controlling the value of the voltage to be applied, or the duration of the voltage application. The more the given energy is, the more the liquid is ejected. It is also acceptable to control the temperature of the printing head that ejects the P liquid. In this case, the higher the temperature is, the more the liquid is ejected. In this embodiment, the latter means was employed, wherein the temperature was approximately 40°C in Step 15, and approximately 32°C in Step 16.

The means for controlling the amount of the ink to be ejected may be different from those described above.

Step 17 is a step in which an image is actually printed; the printing head unit 103 prints  
5 letters and images on the print medium while moving as illustrated in Figures 6 and 7.

In the case of the four pass printing, the amount of the P liquid to be ejected can be further reduced. In other words, a point of the present invention is  
10 that the greater the number of the passes is, the further the amount of the P liquid to be ejected can be reduced. Generally speaking, the number of the passes is increased when it is necessary to improve print quality even if printing time has to be  
15 sacrificed. It should be noted here that reducing the amount of the P liquid to be ejected is also effective for reducing the number of the cockling which occurs on the print medium during printing; therefore, it is possible to produce a print of higher quality.  
20 Further, reducing the amount of the P liquid to be ejected means reducing the overall consumption of the P liquid; therefore, it is effective to reduce the running cost.

In this embodiment, an example, in which the  
25 greater the number of the passes, the further the amount of the P liquid to be ejected can be reduced, was described. This means in more general terms that



the greater the number of the passes, the smaller the amount of the P liquid to be ejected per unit area can be. This may be accomplished by controlling the ejection data for the P liquid without changing the total amount of the P liquid to be ejected. More specifically, the P liquid printing data for the single pass printing are the logical sum of the data for the Y, M, C and Bk colors, but in the case of the double pass printing, the logical sum of the Y, M, C and Bk data is masked, being reduced to 66% thereof in average. It is also acceptable to control both, the amount to be ejected and the ejection data. In either case, the obtainable results are the same.

Figure 14 presents the data to be used for ejecting the Y, M, C and Bk inks, and the P liquid from the print head unit, wherein (a) designates the input data for printing; (b), the data for Y ink; (c), the data for the M ink; (d), the data for the C ink; (e), the data for the Bk ink; and (f) designates the data for the P liquid. The print duty for the P liquid is changed in response to the selected printing mode; the greater the number of the passes is, the smaller the print duty is.

The Y, M, C and Bk inks used in this embodiment had the following composition, wherein the dyes are correspondent to the Y, M, C and Bk colors:

Glycerine

5.0 wt.%

	Thioglycol	5.0 wt.%
	Urea	5.0 wt.%
	Isopropyl alcohol	4.0 wt%
	Dye	3.0 wt.%
5	Water	78.0 wt.%

The P liquid had the following composition:

	Polyallylamine hydrochloride	1.0 wt.%
	Benzalkonium chloride	1.0 wt.%
	Thioglycol	10.0 wt.%
10	Acetylenol EH	0.5 wt.%
	Water	87.5 wt.%

Before or after the Y, M, C and Bk inks were deposited on plain paper, the P liquid having the above composition was deposited thereon, yielding a water resistant print with preferable color development.

#### Embodiment 2

In the first embodiment, the amount of the P liquid to be used was changed in response to the printing mode, but the control is not limited to those described in the first embodiment. For example, the type of the P liquid may be changed in response to the printing mode; the greater the number of the passes is, the smaller the surface tension of the P liquid to be used may be.

Figure 8 is a front view of the printing head comprising a head unit for ejecting a P1 liquid, and a

head unit for ejecting P2 liquid, wherein the P1 and P2 liquids are different in the surface tension, which is accomplished by means of varying the surfactant contents between the P1 and P2 liquids.

5           The specific compositions for the P1 and P2 liquids are as follows, wherein the compositions of the Y, M, C and Bk inks are the same as the first embodiment:

	P1 liquid	
10	Polyallylamine hydrochloride	1.0 wt.%
	Benzalkonium chloride	1.0 wt.%
	Thioglycol	10.0 wt.%
	Acetylenol EH	0.5 wt.%
	Water	87.5 wt.%
15	P2 liquid	
	Polyallylamine hydrochloride	1.0 wt.%
	Benzalkonium chloride	1.0 wt.%
	Thioglycol	10.0 wt.%
	Acetylenol EH	0.2 wt.%
20	Water	87.8 wt.%

Figure 9 is a flow chart for the printing operation in this second embodiment. Steps 21 - 24 are the same as Steps 11 - 14 of the preceding Embodiment 1.

25           In Step 25, which is a part of the single pass printing operation, the P1 liquid having a relatively large surface tension is selected as the P

liquid.

In Step 26, which is a part of the double pass printing operation, the P2 having a relatively small surface tension is selected as the P liquid.

5           It is because of the following reason why the greater the number of the passes is, the smaller the surface tension of the P liquid to be used can be. When printing, in particular, on plain paper, quick-drying properties are desired; therefore, it is  
10   desirable for the ink to have a larger surface tension, which give the ink the properties to permeate quickly the paper. This is also true with the P liquid. Such properties are certainly appreciated in the case of the single pass printing suitable for high  
15   speed printing. However, since the ink with the larger surface tension quickly permeate the paper, a relatively small amount of the coloring component remains on the surface of the paper, and also, the amount of the feathering increases, which gives the  
20   ink disadvantages in terms of the print quality. On the other hand, in the case of the double pass printing suitable for producing a high quality print, the amounts of the color inks and P liquid, which are ejected per unit time and per unit area of the paper  
25   (print medium), are relatively small; accordingly, the need for the quick drying properties is lessened, allowing subsequently the surface tension to be

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reduced. As a result, more coloring components remains on the paper surface, and also, the feathering can be reduced.

Embodiment 3

5           When a monochromatic (B/W) mode was available among the printing modes, the amount of the P liquid to be ejected per unit area of the print medium was varied between the monochromatic and color modes, which gave preferable results.

10           In the case of the printing operation of this embodiment, the Bk ink was ejected at 80 pl per picture element, and the Y, M and C inks were ejected at 40 pl per picture element. The reason why more Bk ink was ejected is that in the case of the Bk ink,  
15           importance was placed on print density, and therefore, the density had to be increased.

Figure 10 is a flow chart for setting the amount of the P liquid when both the monochromatic and color mode are available.

20           In Step 31, it is determined whether the printing mode is the monochromatic or color mode. This determination is dependent on the data from the host computer connected to the printing apparatus, or the selection made through a group of switches. Then,  
25           either Step 32 or 33 is taken in response to the result of the printing mode determination.

Step 31 is the step to be followed when the

monochrome mode is selected, and the amount of the P liquid to be ejected per unit area of the print medium is set to be relative larger. As for the means therefor, the amount of the P liquid to be ejected is set at 30 pl per picture element with a resolution of 360 dpi.

Step 32 is the step to be followed when the color mode is selected, and the amount of the P liquid to be ejected per unit area of the print medium is set to be relatively small. As for the means therefor, the amount of the P liquid to be ejected is set at 20 pl per picture element, with the resolution being 360 dpi.

In Step 34, the normal printing operation is carried out in response to the setting selected as described above. More specifically, in the monochrome mode, the P liquid is ejected onto proper points on the basis of the P liquid deposition data derived from the data for the Bk ink to be ejected, and then, the Bk ink is ejected thereon. In the color mode, the P liquid is deposited on proper points on the basis of the P liquid deposition data derived from the data for the Bk, C, M or Y ink to be ejected, and then, the Bk, C, M or Y ink is ejected thereon.

In principle, it is preferable to reduce the P liquid usage as much as possible. The optimum amount of the P liquid to be ejected varies depending

on the compositions of the ink and P liquid, but as long as the high reliability and high image quality can be maintained, it is desirable to deposit the minimum amount of the P liquid so that the running  
5 cost can be reduced.

In the monochrome mode, the ink to be deposited is always the Bk ink, which is ejected by a relatively larger amount, and the emphasis is on printing letters. When printing letters, importance  
10 is placed on water resistance, more often than not, which is different from when printing picture images, and therefore, it is necessary to increase the amount of the P liquid to be ejected per unit area. On the other hand, in the case of the color mode, which  
15 involves the Y, M and C inks, the inks are deposited by a relatively small amount in comparison with the case of the monochrome mode, and also, more often than not, picture images are printed; therefore, it is possible to reduce the amount of the P liquid to be  
20 ejected per unit area of the print medium, in comparison with the monochrome mode.

As for the specific means for reducing the amount of the P liquid to be deposited per unit area of the print medium, there are three means: the first  
25 one is to reduce the volume of each liquid droplet; the second one is to lower the print duty; and the third one is the combination of the preceding two.

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This embodiment was described with reference to the method for reducing the volume of each liquid droplet, but the present invention is not limited by this embodiment, and other means may be employed.

5 Embodiment 4

In this embodiment, the P liquid usage was optimized for the Bk and color (Y, M and C) inks, which produced preferable results. Also in this embodiment, when printing, the Bk ink was ejected at  
10 80 pl per picture element, and the Y, M and C inks were ejected at 40 pl per picture element. This is because in the case of the Bk ink, importance was placed on the print density, and therefore, the amount the ink to be ejected was increased in order to  
15 increase the density. Because of the same reason as the one given in Embodiment 3, it is not desirable to use the same P liquid for the Bk and color inks.

As is evident from the foregoing, even in the case of a printing mode for producing a color print  
20 with mixed colors of Bk, Y, M and C inks, it is desirable to vary the amount of the P liquid to be ejected, between the Bk ink and the Y, M and C inks, or between the primary and secondary color, so that the amount becomes optimum for each color.

25 Figure 11 depicts the flow of a single scan printing operation, in which the amount of the P liquid to be deposited per unit area of the print



medium is controlled on the basis of whether the printing data is for the Bk ink or the Y, M and C inks.

Step 41 is a step in which it is determined  
5 for each picture element whether the printing data are for the Bk ink or the others (Y, M and C inks). When they are for the Bk ink, Step 42 is taken, and otherwise, the operation moves to Step 43.

Step 42 is the step to be taken when the  
10 printing data are for the Bk ink, in which the P liquid data are created in such a manner than the amount of the P liquid to be deposited per unit area of the print medium becomes relatively large. In this embodiment, the deposition data themselves are left  
15 unchanged, and instead, the amount of the liquid to be ejected per picture element is set at a higher level, that is, at 30 pl.

Step 43 is the step to be taken when the printing data are for the others, in which the P  
20 liquid data are created in such a manner as to reduce the amount of the P liquid to be ejected. In this embodiment, the amount of the liquid to be deposited per picture element is set at a reduced level, that is, at 20 pl.

25 In Step 44, the data equivalent to a single scanning line are produced, with the amount of the P liquid to be ejected per Bk picture element being set

at 30 pl.

In Step 45, the data for a single line of scanning are produced, with the amount of the P liquid to be ejected per picture element of the other inks  
5 being set at 20 pl.

In Step 46, a normal printing operation is carried out (the P liquid, and the Y, M and C inks, are deposited) by a single scanning line, using the liquid data produced as described above, for the P  
10 liquid, Bk ink, and Y, M and C inks.

In this embodiment, the amount of the P liquid to be ejected per pixel was modulated by means of controlling the energy given to the P liquid head. The control was executed so that it took more energy  
15 to eject the P liquid at 30 pl than at 20 pl.

In the case of a color print containing the Y, M and C inks, preferable results could be obtained by means of varying the printing process on the basis of whether the color inks are deposited so as to be  
20 independent from each other in order to create the primary colors, or overlaid upon each other to create the secondary colors such as R, G or B color.

Figure 12 presents the flow of a single scan printing operation, in which the amount of the P  
25 liquid to be ejected per unit area of the print medium is controlled on the basis of whether the printing data are for the primary colors of black, yellow,

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cyan, and magenta, or the secondary colors such as red, blue, or green.

In Step 51, it is determined for each pixel whether the printing data are for the Bk ink. When  
5 they are for the Bk ink, Step 52 is taken, and when they are for the others, Step 53 is taken.

In Step 53, it is determined for each pixel whether the colors are primary or secondary. When  
they are primary, Step 54 is taken, and when  
10 secondary, Step 55 is taken.

Step 52 is the step to be taken when the printing data are for the Bk ink, in which the P liquid data are produced so as to increase the amount of the P liquid to be ejected. In this embodiment, it  
15 was set at a relatively large level of 30 pl.

Step 54 is the step to be taken when the printing data are for the primary colors Y, M and C, in which the P liquid data are created so as to reduce the amount of the P liquid to be ejected. In this  
20 embodiment, it was set at a relatively low level of 20 pl.

Step 55 is the step to be taken when the printing data are for the secondary colors R, G and B composed of the primary colors Y, M and C, in which  
25 the P liquid data are produced so as to increase the amount of the P liquid to be ejected. In this embodiment, it was set at a relatively high level of

30 pl.

In Step 59, a normal single scan printing operation is carried out under the printing condition set as described above.

5 In this embodiment, the amount of the P liquid to be ejected was variably controlled by means of controlling the amount of the energy to be given to the heating member and/or varying the wave-form of the power given thereto to drive it. However, the present  
10 invention is not limited by this embodiment, and other means may be employed. For example, two or more heat generating members may be disposed at the ejection outlets, to be selectively activated.

When the amount of the P liquid to be ejected  
15 was optimized, as describe above, in response to the printing data, preferable results could be obtained.

#### Embodiment 5

When all of the printing heads for the Bk, Y, M and C colors, and the P liquid ejecting head, are  
20 driven at the same time, the instantaneous maximum electric power consumed by the printing apparatus increases. In this case, it is effective to employ a method in which in order to lower the instantaneous maximum power consumption, the number of the  
25 simultaneously driven heads is reduced.

Referring to Figure 6, the instantaneous maximum power consumption can be reduced to 4/5, by

means of driving the P liquid head when the printing head unit 103 is scanning in the the direction of the arrow mark A, and the Bk, Y, M and C ink heads when the printing head unit 103 is scanning in the

5 direction of the arrow mark B. Such a means offers merits in that it reduce the cost since the reduction in the maximum power consumption allows the size of the power supply section of the printing apparatus to be reduced. In this case, if the Y, M, C and Bk inks

10 are ejected after a relatively long time, on the order of several seconds, following the ejection of the P liquid, the P liquid may not be so effective. Therefore, it is essential that the Y, M, C and Bk inks be deposited immediately after the P liquid

15 deposition. This can be accomplished in the following manner; namely, immediately after the P liquid is ejected from the printing head which is moving in one of the main scanning directions, the Y, M, C and Bk inks are ejected from the printing head which is

20 moving this time in the reverse direction.

Further, when the printing head unit 103 structured as illustrated in Figure 2 is employed, the maximum instantaneous power consumption can be reduced to  $3/5$ , since this structure makes it possible to

25 activate the printing heads in such a manner that when the printing head unit 103 is moved in the scanning direction indicated by the arrow mark A, the P liquid

and Bk ink head are activated in this order, and next, when moved in the direction indicated by the arrow mark B, the printing heads for the Y, M and C inks are activated.

5           As is evident from the above descriptions, the separation of the P liquid ejection from the ejection of the other liquids (Y, M and C inks) has its merits in that the maximum instantaneous power consumption of the printing head unit can be reduced.

10           Figure 13 is a front view of another printing head unit. The unique characteristic of this printing head unit is that the P liquid head is disposed between the Bk ink head and the C ink head.

For example, when the printing head unit  
15 scans in the arrow mark B direction, only the P liquid head and the Bk ink head are activated, the former being activated on the basis of the Data for the Bk ink; and when the printing head unit scans in the arrow mark A direction, only the P liquid head and the  
20 heads for the Y, M and C inks are activated, the former being activated on the basis of the data for the Y, M and C inks.

This is because the above arrangement also has its own merits in that the conditions for driving  
25 the P liquid head can be relatively easily changed between when the Bk ink is ejected during the scanning movement of the printing head unit in the arrow mark B

direction and when the Y, M and C inks are ejected during the scanning movement of the printing head unit in the arrow mark A direction. This is because the conditions for driving the P liquid head can be more easily controlled for each scanning movement than for each pixel.

For example, when scanning in the arrow mark A direction, the voltage for driving the P liquid head is lowered to reduce the amount of the P liquid to be ejected from the P liquid head, and when scanning in the arrow mark B direction, the driving voltage for the P liquid head is raised to increase the P liquid ejection from the P liquid head. This arrangement allows more P liquid to be ejected when followed by the Bk ink, and less P liquid to be ejected when followed by the Y, M and C inks.

The driving voltage is switched when the primary scanning direction is switched between the arrow marks A and B directions. This method also has its own merits in that the driving voltage can be more easily switched in comparison with when the driving voltage is switched for each dot.

It should be noted here that in the preceding embodiments, dyes were used as the coloring material, but the present invention is not limited by the embodiments, and pigment may be used as the coloring material.

The print quality improver liquid, which renders the ink dye insoluble, can be obtained, for example, in the following manner.

First, the components list below are mixed.

- 5 After they dissolve, the solution is filtered, with application of pressure, through a membrane filter having a pore size of 0.22  $\mu$ m (commercial name: Fluoro Pore Filter; Sumitomo Electric Industries, Ltd.). Then, the pH of the filtered solution is adjusted to
- 10 4.8 using NaOH, yielding print quality improver liquid A1.

[A1 components]

Cationic compound of low molecular weight

- Stearyl trimethylammonium chloride 2 parts
- 15 (commercial name: Electro-stopper QE; Kao Corp.)

Cationic compound of high molecular weight

Polyaminesulfon (average molecular weight:  
5000) 3 parts

(commercial name: PAS-92; Nitto Boseki Co., Ltd.)

- 20 Thioglycol 10 parts
- Water rest

As for the preferable inks which are rendered insoluble when mixed with the above print quality improver liquid, the following can be listed:

- 25 First, the components listed below are mixed, and then, the solution is filtered, with application of pressure, through a membrane filter (commercial



name: Fluoro Pore Filter; Sumitomo Electric Industries, Ltd.) having a pore size of 0.22  $\mu\text{m}$ , yielding the yellow Y1, magenta M1, cyan C1, and black Bk1 inks.

5 Y1

C. I. direct yellow 142	2 parts
Thioglycol	10 parts
Acetylenol EH (Kawaken Fine Chemical)	0.05 part
Water	rest

10 M1

Acid red 2892.50 parts  
(rest are the same as Y1)

C1

Acid blue 9	2.5 parts
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(rest are the same as Y1)

15

Bk1

Food black 2	3 parts
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(rest are the same as Y1)

20 According to this embodiment, the  
aforementioned print quality improver liquid (liquid compound) and inks are caused to mix with each other on the surface of the print medium, or in the print medium as they permeate therein. At the initial stage of the reaction, the low molecular weight cationic  
25 component or cationic oligomer, which are contained in the print quality improver liquid, ionically react with the water soluble dye, which is used in the ink

and contains anionic radicals or anionic compound in the case of the pigment ink, and instantly separate from the solution. More specifically, in the case of the pigment ink, the the pigment dispersion  
5 equilibrium is disturbed, yielding thereby pigment aggregates.

In the second stage, the aforementioned associative polymers composed of the dye and cationic substance of low molecular weight, associative  
10 polymers composed of the dye and cationic oligomer, or the pigment aggregate is absorbed (adsorbed) by the high polymers contained in the print quality improver solution; therefore, the dye aggregate or pigment aggregate, which are yielded as the results of the  
15 associative polymerization, further increase its size, which makes it difficult for the dye aggregate or pigment aggregate to move into the gaps among the print medium fibers. As a result, only the solvent portion, from which the solute portion has separated,  
20 permeates the print medium, accomplishing both objectives: improvements in the print quality and fixation of the ink. At the same time, the associative polymer that are composed, through the aforementioned mechanism, of the low weight molecules  
25 among the cationic molecules and anionic dye, or are composed of the cationic oligomer and anionic dye, or the pigment aggregates, does not move with the solvent

due to the increased viscosity. Therefore, even when the adjacent ink dots are composed of the inks of different colors as they are in a full-color print, the color generating components do not mix with each other to cause bleeding. The aforementioned aggregates are insoluble in water in its basic nature, which makes the formed image perfectly water resistant. There is an additional benefit; the shielding effects of the polymer improves the formed image in its resistance to the light.

As for the insolubilizing or aggregating process described in this specification, it occurs only in the initial stage in one example, and it occurs in both the initial and second stages in another example.

In the practical application of the present invention, it is unnecessary to use the cationic high polymer or polyvalent metallic salt, which has a high molecular weight, as it is used in the case of the conventional technology; or even when it is necessary to use it, all that is needed is to use it in an auxiliary terms in order to enhancing the effects of the present invention. Therefore, the amount can be minimized. As a result, the deterioration of the color developing performance of the dye, that is, the problematic aspect of the conventional technology, which manifests when an attempt is made to effect

water resistance using the cationic high polymer or polyvalent metallic salt, can be prevented.

Also in the practical application of the present invention, there is nothing to limit the print medium choice. Preferable results can be obtained using so-called plain paper such as conventional copy paper, bonded paper, or the like. Needless to say, preferable results can be also obtained using coated paper produced specifically for ink jet printing, or transparent film to be used with an OHP, as well as commonly used high quality paper or high gloss paper.

As described above, according to the present invention, the amount of the print quality improver liquid to be ejected per unit area of the print medium is controlled on the basis of the number of scanning passes in each printing mode, the color of the ink to be ejected from the head, that is, whether printing is carried out monochromatically or in color, and/or the printing data; and also, the print quality improver liquid most suitable for each printing mode is selected; therefore, it is possible to produce a highly reliable image of high quality.

Further, the printing quality improver liquid is ejected during its own scanning pass different from the one for at least one or all of the Bk, Y, M and C inks; therefore, it is possible to reduce the maximum instantaneous power consumption of the printing

apparatus, which is effective to reduce the apparatus size and lower the running cost.

Next, Embodiments 6 - 8, which represent the second form of the present invention, will be  
5 described with reference to Figures 18 - 30.

Embodiment 6

Figures 18 - 30 depict an embodiment of ink jet recording apparatus in accordance with the present invention. Figure 18 is a schematic perspective view  
10 of the printer portion of the ink jet recording apparatus in accordance with the present invention. Figure 19 is a schematic perspective view of the carriage of the printer section illustrated in Figure 18. Figure 20 is an enlarged, exploded perspective  
15 view of the carriage illustrated in Figure 18. Figure 21 is a perspective view depicting a recording head mountable on the carriage illustrated in Figure 20, and an ink container mountable replaceably on the recording head. Figure 22 is an exploded perspective  
20 view of a fixing member which connects electrically the contact portion of the recording head, and the main assembly of the apparatus. Figure 23 is an exploded perspective view illustrating the carriage of the printer section, and a means for detecting the  
25 carriage position. Figure 24 is a schematic perspective view illustrating a structure for fixing the positional relationship between the carriage of

the printer section, and the head base of the recording head. Figure 25 is a schematic side view of a fixing means for making reliable the positional relation fixing structure illustrated in Figure 24.

5 Figure 26 is a schematic sectional view of the fixing member for connecting electrically the contact portion of the recording head, and the main assembly of the apparatus. Figure 27 is a schematic sectional view illustrating how an FPC holder and the recording head  
10 are engaged. Figure 28 is a sectional side view of the recording head and ink container, which are on the carriage. Figure 29 is a perspective external view of an embodiment of the ink jet recording apparatus in accordance with the present invention. Figure 30 is a  
15 block diagram for describing the control system of the embodiment of the ink jet recording apparatus in accordance with the present invention.

To begin with, the general structure of the ink jet recording apparatus will be described with  
20 reference to Figure 18.

The printer portion illustrated in Figure 18 generally comprises a sheet feeder portion 2001, a carriage portion 3002, a purge portion 3003, a casing portion 3004, a recording head portion 3003, and an  
25 ink container portion 3009.

The sheet feeder portion 3001 generally comprises a platen roller 3106, a pinch roller 3107,

which presses the recording medium having been delivered onto the platen roller 3107 so that the recording medium is prevented from hovering or acting likewise, and is reliably conveyed toward a carriage portion 3002. The platen roller 3106 is connected to the sheet feeder motor (unillustrated) by way of a transmission mechanism comprising a conveyer roller gear 3108 and a conveyer roller idler gear (unillustrated), and rotates as it receives the driving force from the motor.

The carriage portion 3002 generally comprises a carriage base 3201 for mounting the recording head portion 3008, and a head lever 3203 for retaining the recording head portion 2003 mounted on the carriage base 3201. The carriage base 3201 is disposed between the lateral walls of a substantially U-shaped chassis 3102, being supported on a guide shaft 3102 and a support shaft 3103, which are parallel to each other, and is movable in the longitudinal direction (hereinafter, primary scanning direction) of the shafts. The rotation of the carriage base 3201 is regulated since it is supported on both shafts 3102 and 3103. The carriage motor 3104 is fixed to one end of the central rear plate of the chassis 3102, and is connected to the carriage base by way of a pair of pulleys 4041 and a timing belt 3105 stretched between the pulleys 4041. As the carriage motor 3104 rotates

forward or backward, the carriage base 3204 is reciprocated by way of the pulleys 4041 and timing belt. The position of the carriage portion 3202 in the primary scanning direction is confirmed by a HP  
5 (home position) sensor (unillustrated) fixed to the chassis 3102. For example, it is possible to confirm whether or not the carriage portion 3002 is at the home position, which is a predetermined position outside the recording region, and also, is where the  
10 carriage portion 3002 is to be parked during a non-recording period.

A purging portion 3003 is mounted on a frame portion 3004, below the home position. It is a unit provided with a mechanism for sucking the ink. When  
15 the ink ejecting outlets of the recording head portion 3008 is clogged up with foreign substance or the like, and as a result, ink ejecting performance is deteriorated or the ink cannot be ejected any more, the waste ink is sucked out of the recording head  
20 portion 3008 parked at the aforementioned home position, by this purging portion 3003, so that the ink ejecting outlets are unplugged to restore the preferable ink ejecting performance.

The frame portion 3004 is provided with a  
25 waste ink container for storing the waste ink sucked out by the purging portion 3003.

Next, the structure of the recording head



portion 3008 will be described with reference to Figure 21.

Since the recording head portion 3008 in this embodiment mainly prints in color, it is of the multi-head type, in which five liquid ejecting subheads are integrally disposed so that the black (Bk), cyan (C), magenta (M) and yellow (Y) inks, and a colorless solution (CL) capable of insolubilizing the dye, can be individually ejected. The recording head portion 3008 is replaceably mountable on the carriage portion 3002 illustrated in Figures 18 - 20, and when its service life expires or it becomes unusable due to some reason, it can be exchanged with a fresh ink jet recording head.

The recording head portion 3008 generally comprises a boxy head base 3801, a contact portion 3802 formed on the top surface of the head base 3801 in order to establish electrical connection between the head base 3801 and the wiring portion of the main assembly of the recording apparatus, and an ink supplying portion 3803 formed on one of the lateral walls of the head base 3801 in order to receive the ink supplied from the ink container portion 3009. This ink supplying portion 3803 is disposed so as to face each of the ink jet recording heads.

The ink container portion 3009 supplies each of the liquid ejecting subheads of the recording head

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portion with the ink or processing liquid, and is replaceably mounted on the carriage portion 3002.

In this embodiment, the carriage portion 3002, on which the recording head portion 3008 and ink container portion 3009 are mounted, is connected to a part of the timing belt 3105 which transmits the driving force of the carriage motor 3104, and reciprocates in the primary scanning direction, sliding on the parallelly arranged guide shaft 3102 and support shaft 3103. The recording is effected in the following manner; as the carriage portion 3002 is driven, the recording head portion 3008 ejects the ink while being shuttled across the entire width of the recording sheet (recording medium) which has been delivered from an unillustrated recording medium feeding apparatus onto the platen roller 3106 which faces the liquid ejecting surface of the recording head portion 3008.

Next, the carriage structure will be described in detail.

Referring to Figures 19, 20 and 21, the carriage portion 3002 can accommodate five liquid ejecting subheads, each of which ejects one of five different liquids: black (Bk), cyan (C), magenta (M) and yellow (Y) inks, and the colorless liquid (CL) (hereinafter, processing liquid) capable of insolubilizing the dye, and five ink container

portions 3009, each of which supplies the correspondent liquid ejecting subhead with the ink or processing liquid.

Referring to Figure 20, a pair of head lever  
5 axes 2023a (only one of them is illustrated) provided  
at corresponding bottom end portions of the lateral  
wall of the substantially U-shaped head lever 3202,  
and a pair of head lever axes bearing portions 2017a  
and 2017b provided at corresponding top end portions  
10 of the substantially L-shaped carriage base 3201, are  
engaged with each other, allowing the head lever 3202  
to rotate about the head lever axis 2023a. Referring  
to Figure 19, as the head lever 3202 is rotated open  
in the direction of an arrow mark, it becomes easier  
15 to mount or demount the recording head portion 3008.  
The opened head lever 3202 can be held open by  
engaging a pair of head lever positioning bosses  
(unillustrated) with a pair of head lever positioning  
holes 2018.

20 In a recess 3208 formed on each of the  
lateral walls of the head lever 3202, a head tension  
spring 3209 and a head tension 3210 are provided,  
wherein the head tension 3210 is held by the claw  
projecting in the recess 3208, against pressure  
25 generated by the compressed head tension spring 3209  
as shown in Figure 25. Therefore, as the head lever  
3202 is rotated after the recording head portion 3008

is mounted on the carriage base 3201, the head tension 3210 comes in contact with the head tension receiving portion 8010a on the corresponding side (there is another one on the other side). Then, as the head  
5 lever 3202 is further rotated, the pressure generated by the head tension spring 3209 is applied, through the head tension 3210, to the head tension receiving portion 8010a in the direction of an arrow mark D, and also, the head lever fixing boss 2024a engages with  
10 the head lever fixing portion 2012a. As a result, the position of the recording head portion 3008 is fixed by the carriage base 3201 and head lever 3202.

On the contrary, when it is necessary to rotates the head lever 3201 to remove the recording  
15 head portion from the carriage base 3201, a pair of head lever release portions 2027 (only 2027a is shown) are pressed to push out the head lever fixing bosses 2024 (only 2024a is shown) so that the head lever fixing bosses are disengaged from the head lever  
20 fixing portions 2012 (only 2012a is shown), which allows the head lever 2020 to be rotated.

Referring to Figure 20, a plurality of carriage ink guide ribs 2011 are provided on the internal surface of the carriage base 3201. They  
25 guide the bottom surface of the ink container portion 3009 when the ink container portion 3009 is mounted, and supports the mounted ink container portion 3009.

Further, a plurality of head lever ink container guide ribs 2021 are provided on the internal surface of the head lever 3202. They guide the top surface of the ink container when the ink container is mounted, and  
5 hold the top surface thereof.

Referring to Figures 18 and 22, a carriage flexible cable 3207 supplies the recording head portion 3008 with image signals and driving signals. The position of the contact portion of the flexible  
10 cable 3207 is fixed by a pair of contact position fixing bosses 2031a and 2031b of an FPC holder 3203, and a rubber pad 3206, being clipped, together with the rubber pad 3206, to the FPC holder 3203 by an FPC holder 3208.

15 The head hook 3205 is fitted to a pair of axes 2032 (only 3032a is shown), which are provided on the corresponding lateral sides of the FPC holder 3203, being thereby ratable. The head hook 3205 is pressured in the inward direction of the FPC holder  
20 3203 by an FPC spring 3204, and also, the FPC holder 3203 is ratable since a pair of FPC holder shaft bearing portions 2033 (only 2033a is shown) of the FPC holder 3203 is engaged with the FPC holder shafts 2022 (only 2022a is shown) of the head lever 3202. The  
25 image signal and driving signals supplied through the carriage flexible cable 3201 are delivered to the recording head portion 3008 by way of the contact

portion 3802 in order to carry out a printing operation.

Referring to Figure 23, a portion of the timing belt 3105 is fixed to the belt stopper 3211  
5 fixed to the carriage base 3201. The carriage flexible cable 3207 is fixed to the carriage base 3201 with the use of a carriage PCB 3213 and CR PCB cover 3214. A linear encoder 3212 is a position detecting sensor to be used for controlling the position of the  
10 carriage portion 3002, and is fixed to the carriage base 3201.

A head lever label 3220 describing clearly the operation for mounting the recording head portion 3008 and ink container portion 3009 on the carriage  
15 portion 3002 may be pasted on the head lever 3202 so that it can be easily accessed by a user, or the contents of the aforementioned label may be stamped on the head lever 3202.

Referring to Figure 24, five bosses are  
20 provided on the carriage base 3201. They fix the position of the recording head portion 3008. The positioning in the direction of an arrow mark A is accomplished by placing cylindrical bosses 8011a, 8011b and 8011c provided on the head base 3801 in  
25 contact with the trapezoidal bosses 2013a, 2013b and 2013c, correspondingly, whereas the positioning in the direction of an arrow mark B is accomplished by

engaging the bosses 2013d and 2013e of the carriage  
base 3201 with the grooves 8011e and 8011e of the head  
base 3801. The width a of the boss 2013d or boss  
2013e is determined in consideration of the width a'  
5 of the groove 8011d or 8011b, respectively. The  
positioning in the direction of an arrow mark C is  
accomplished by placing the top portions of the curved  
surface portions of the bosses 2013d and 2013e of the  
carriage base 3201 in contact with the top portions of  
10 the groove 8011d and 8011e of the head base 3801,  
respectively.

Figure 25 is a simplified drawing to depict  
how the recording head portion 3008 is fixed to the  
carriage base 3201 with the head lever 3202. As is  
15 evident from Figure 25, the head tension receiving  
portion 8010a of the recording head portion 3008 is  
pressured by the head tension 3210, which is under the  
pressure generated in the direction of an arrow mark D  
by the head tension spring 3209 attached to each of  
20 the lateral walls of the head lever 3202 to fix the  
position of the recording head portion 3008. As a  
result, the recording head portion 3008 is fixed at a  
predetermined position on the carriage base 3201.

Figure 26 is a schematic drawing of the  
25 recording head portion 3008 fixed by the head lever  
3202.

Its position is fixed as the contact position

fixing bosses 2031a and 2031b of the FPC holder 3202 engage with the contact position fixing holes 8021a and 8021b of the recording head portion 3008, respectively. The engagement of the contact position fixing bosses 2031a and 2031b also fixes the positions of the rubber pad 3206 and carriage flexible cable 3207. The head hooks 3205 engage with the head hook accommodating portions 8012a and 8012b of the recording head portion 3008, on the corresponding sides. After the engagement, the rubber pad 3206 is in the state of being compressed, generating thereby the pressure to press the carriage flexible cable 3207 so that the electrical connection is established between the carriage flexible cable 3207 and the recording head portion 3008. As the head lever 3203 is rotated, the release claws 2026a and 2026b of the head lever 3202 rotate the head hooks 3205 in the direction of an arrow mark F, and as a result, the head hooks 3205 is disengaged from the head hook accommodating portions 8012a and 8012b of the recording head portion 3008, whereby the engagement between the recording head portion 3008 and the head hook 3205 is broken. Further, the power supplied from the main assembly side to the recording head portion 3008 can be interrupted by means of disengaging the carriage flexible cable 3207 from the contact point of the recording head portion 3008.



Figure 27 is a schematic sectional view of the recording head portion 3008, being engaged with the FPC holder 3203.

The FPC holder 3203 is rotatable about the FPC holder shaft 2022 of the head lever 3202 since the shaft 2022 is fitted in the FPC holder shaft bearing portion 2033 of the FPC holder 3203; wherein they are fitted with some play. The tip of the contact position fixing boss 2031 of the FPC holder 3203 is shaped like a slantingly cut cylinder as shown in Figure 27, so that the FPC holder 3203 can smoothly fit into the contact position fixing hole 8021 as it rotates about the FPC holder shaft 2022.

In this embodiment, the FPC holder 3203 is not a part of the head lever 3202, and some play is allowed between the two members; therefore, the established electrical connection between the recording head portion 3008 and the main assembly does not interfere with the process for fixing the position of the recording head portion 3008 on the carriage base 3201.

Figure 28 is a sectional side view of the recording head portion 3008 and ink container portion 3009, which are on the carriage portion 3002.

The ink container portion 3009 is of a so-called hybrid type, which contains two chambers, wherein, as seen from the direction of a supply port

9011, a front chamber is filled with an absorbent member 3902, and a rear chamber stores the ink 3903. As the ink container portion 3009 is attached to the recording head portion 3008, the ink supplying portion 5 3803 of the recording head portion 3008 presses the absorbent member 3902 of the ink container portion 3009, compressing thereby a part of it, whereby the ink container portion 3009 is pressured in the direction of an arrow mark I. However, the ink 10 container portion 3009 is fixed on the carriage base 3201 so that the movement of the ink container portion 3009 in the direction of the arrow mark I is prevented. Therefore, the ink 3903 having been absorbed in the absorbent member 3902 is supplied to 15 the ink jet recording head through the ink supplying portion 3803.

The carriage base 3201 is provided with a guide portion 2015b having a quadrantal section, and the ink container portion 3009 is smoothly mated with 20 the recording head portion 3008 as it slides down on the curved surface portion of the guide portion 2015b. As for the removal of the ink container portion 3009, it can be easily accomplished by means of pushing up the knob 9015 in the direction of an arrow mark J. 25 The waste ink from the ink supplying portion of the recording head portion 3008 and the ink supply port of the ink container portion 3009 is delivered to the

purging portion 3003 or the like disposed below,  
through the waste ink portion 2016 of the carriage  
base 3201.

Figure 29 is a perspective external view of  
5 an embodiment of the ink jet recording apparatus in  
accordance with the present invention.

The ink jet recording apparatus in accordance  
with the present invention is provided with a control  
panel portion 3007, which is located on the top  
10 surface thereof, and comprises a power source key or  
the like, as well as keys for selecting the various  
functions of the ink jet recording apparatus.

Figure 30 is a block diagram of the control  
system in an embodiment of the ink jet recording  
15 apparatus in accordance with the present invention.

The recording operation of this ink jet  
recording apparatus is controlled by a control section  
3006 comprising: a MPU 3601 which controls the overall  
operation of the apparatus while exchanging signals  
20 with the various sections of the recording apparatus;  
an ROM 3602 which stores the programs for the  
recording operations or processes, or the like; an RAM  
3603 to be used as a recording data buffer or an work  
area for the processes carried out by the MPU 3601;  
25 and input-output signal port 3604. Namely, the signal  
from the control section 3006 is delivered to driver  
circuits 3606, 3607 and 3608 through the input-output

signal port 3604, which drives the carriage motor  
3104, sheet feeder motor 3100, and the recording head  
portion 3008, respectively. Also, the control section  
3006 receives the recording data from a computer as  
5 the host apparatus, through an interface circuit 3605.  
An operator can control the recording apparatus by  
means of manipulating the keys and the like provided  
in the control panel portion 3007. As was described  
before, the linear encoder 3212 as the position  
10 detecting sensor is a means for detecting the position  
of the carriage portion 3002.

The water resistance can be surely obtained  
by means of ejecting the dye containing color ink  
immediately after the ejection of the processing  
15 liquid. However, when the water resistance is  
unnecessary: for example, when a transparent sheet  
such as a sheet of PET (polyethyleneterephthalate) or  
the like is pasted on the recorded surface after the  
completion of the printing; when a user test-prints  
20 the images in order to confirm the produced printing  
data (text and/or picture image); or when the images  
are printed on an OHP sheet or so-called coated paper,  
that is, the recording medium constituted of a sheet  
of base material and an ink receptive layer coated  
25 thereon, a "no water resistance" key 3701 provided in  
the control panel portion is to be selected by the  
user, so that the head provided in the recording head

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portion for ejecting the processing liquid is  
controlled by the MPU 3601 working in conjunction with  
the ROM 3602, by way of the input-output signal port  
3604 of the control section 3006, so as not to eject  
5 the processing liquid.

In the case described in the foregoing, the  
ejection of the processing liquid is directly canceled  
by the user, but it may be indirectly canceled by  
means of providing the driver of the computer as the  
10 host apparatus, with a means for selecting "no water  
resistance," which replaces the direct involvement of  
the use. In the latter case, the head provided in the  
recording head 3008 for ejecting the processing liquid  
is controlled by the MPU 3601 working in conjunction  
15 with the ROM 3602, through the interface circuit 3605  
and the input-output signal port 3604 of the control  
section 3006, so as not to eject the processing  
liquid.

#### Embodiment 7

20 In the preceding Embodiment 6, a user selects  
the "no water resistance" key 3701 provided in the  
control panel portion 3007 to cancel the ejection of  
the processing liquid; whereas in this embodiment,  
when a trial printing key 3701 provided in the control  
25 panel portion 3007 for carrying out, for example, a  
draft mode printing (speed oriented printing mode such  
as low density printing mode) is selected, the

ejection of the processing liquid is canceled.

Also, in the preceding embodiment, the ejection of the processing is canceled when the user selects the trial printing key 3701 provided in the control panel portion 3007, but it may canceled by means of providing the driver of the computer as the host apparatus, with a means for selecting the trial printing mode. In this case, the subhead provided in the recording head portion 3008 for ejecting the processing liquid is controlled by the MPU 3601 working in conjunction with the ROM 3602, through the interface circuit 3605 and the input-output signal port 3604 of the control section 3006, so as not to eject the processing liquid.

Embodiment 8

When processing liquid is coated on the OHP sheet, coated sheet, or the like, that is, the recording medium constituted of the base sheet and the ink receptive layer coated thereon, the inferior printed image is produced. In this embodiment, such a problem is eliminated by providing the ink jet recording apparatus with a function for allowing the user to input the recording medium selection, or a function for detecting automatically the type of the recording medium. In the latter case, the ejection of the processing liquid is controlled (whether or not the processing liquid is to be ejected is determined)

in response to the recording medium type discriminated  
by the MPU 3601 as the recording medium discriminating  
means, and the ROM 3602 storing the printing  
controlling means; therefore, the time the user spends  
5 to make direct selection can be eliminated.

Further, the ink to be used in this  
embodiment of the present invention is not limited to  
be the dye ink. The pigment ink in which the pigment  
is dispersed may be used, and in this case, the  
10 processing liquid is of a type which aggregate the  
pigment. As for an example of the pigment ink in  
which aggregation occurs when mixed with the  
aforementioned processing liquid A1, the following  
ones can be listed: yellow Y2, magenta M2, cyan C2,  
15 and black K2 inks, which contain correspondent color  
pigment and anionic compound.

Black Ink K2

Anionic high polymer P-1 (styrene-  
methacrylate-ethylacrylate; acid number: 400; weight  
20 average molecular weight: 6,000; water solution  
containing solid content by 20 %; neutralizer:  
potassium hydroxide), which was used as the  
dispersant, and the following components, were  
subjected to a dispersing process for three hours in a  
25 batch type vertical sand mill (product of Imex), using  
glass beads (1 mm in diameter) as media, while being  
cooled with water. After the dispersion, the

viscosity and pH were 9 cps and 10.0, respectively. This dispersion was placed in a centrifugal separator to remove coarse particles, producing thereby a solution dispersed with carbon black having a weight  
5 average particle diameter of 100 nm.

(Composition of Carbon Black Dispersion)

	P-1 water solution	40 parts
	(20 % solid contents)	
	Carbon black Mogul L	24 parts
10	(product of Cablack)	
	Glycerine	15 parts
	Ethylene glycol monobutylether	0.5 part
	Isopropyl alcohol	3 parts
	Water	135 parts

15           Next, the obtained dispersion was sufficiently diffused to produce the ink jet black ink K2 containing the pigment. The solid contents in the final product was approximately 10 %.

Yellow Ink Y2

20           Anionic high polymer P-1 (styrene-acrylate-methylmethacrylate; acid number: 280; weight average molecular weight: 11,000; water solution containing 20 % solid content; neutralizer: diethanolamine), which was used as the dispersant, and the following  
25 components, were subjected to the same dispersing process as the black ink K2, producing thereby a yellow dispersion containing yellow color pigment



having a weight average particle diameter of 100 nm.

(Composition of Yellow Pigment Dispersion)

	Water solution P-2	35 parts
	(20 % solid contents)	
5	C.I. pigment yellow 180	24 parts
	(Novapalm Yellow PH-G, available from Hechst)	
	Triethylene glycol	10 parts
	Diethylene glycol	10 parts
	Ethylene glycol monobutylether	1 part
10	Isopropyl alcohol	0.5 part
	Water	135 parts

Next, the obtained dispersion was sufficiently diffused to produce the ink jet yellow ink Y2 containing the pigment. The solid contents in  
15 the final product was approximately 10.0 %.

Cyan Ink C2

The same anionic high polymer P-1 used for producing the black ink K2, which was used as the dispersant, and the following components, were  
20 subjected to the same dispersing process as the carbon black dispersion, producing a cyan dispersion containing cyan pigment with a weight average particle diameter of 103 nm.

(Composition of Cyan Pigment Dispersion)

25	Water solution P-1	30 parts
	(20 % solid contents)	
	C.I. pigment blue 15:3	24 parts

(Fastgemble-FGF, available from Dainippon  
Ink Chemistries)

	Glycerine	15 parts
	Diethyleneglycol monobutylether	0.5 part
5	Isopropyl alcohol	3 parts
	Water	135 parts

Next, the obtained cyan pigment dispersion  
was sufficiently stirred to produce the ink jet cyan  
ink C2 containing the pigment'. The solid contents in  
10 the final product was approximately 9.6 %.

Magenta Ink M2

The same anionic high polymer P-1 used for  
producing the black ink K2, which was used as the  
dispersant, and the following components, were  
15 subjected to the same dispersing process as the carbon  
black dispersion, producing a magenta dispersion  
containing magenta pigment with a weight average  
particle diameter of 115 nm.

(Composition of Magenta Pigment Dispersion)

20	Water solution P-1	20 parts
	(20 % solid contents)	
	C.I. pigment red 122	24 parts
	(available from Dainippon Ink Chemistries)	
	Glycerine	15 parts
25	Isopropyl alcohol	3 parts
	Water	135 parts

Next, the obtained magenta pigment dispersion

was sufficiently diffused to produce the ink jet magenta ink M2 containing the pigment. The solid contents in the final product was approximately 9.2 %.

As described above, according to the present invention relating to an ink jet recording apparatus which forms images by means of ejecting ink and/or processing liquid onto recording medium, whether or not the processing liquid is to be used is determined by a user so that the processing liquid is not wasted, and also, the recording apparatus itself can be programmed so that the processing liquid is not ejected when the recording medium requiring no processing liquid is used, or when the test-printing is done. Therefore, the cost of the actual printing operation can be reduced. As a result, an ink jet recording apparatus capable of reducing the overall running cost can be provided.

Hereinafter, Embodiments 9 - 18 as the third form of the embodiment will be described with reference to Figures 31 - 48.

The print quality improver liquid (hereinafter, P liquid or processing liquid) in the present invention is liquid which is to be applied to print medium to improve the quality of the print produced through the ink jet printing. The print quality improvement includes: improvement in image properties such as density, saturation, sharpness of

edge, dot diameter; improvement in ink fixability to recording medium; and improvement in preservability of printed image, that is, environmental resistance such as water resistance, light resistance, or the like.

5           In the following description, "environment" sometime includes the type of the print medium. Further, according to the present invention, the liquid ejecting portion may be a part of the same head, or a separate head.

10   Embodiment 9

Figure 31 is a perspective view of a printing apparatus to be used to embody the printing method in accordance with the present invention, and illustrates its general structure.

15           The liquid ejecting portion 4102 of a printing apparatus 4100 is a printing means capable of ejecting each of four color inks: Y, M, C and Bk inks, and the P liquid, and is capable of reciprocating in the direction parallel to the axial line of a sheet  
20 feeder roller 4109 (hereinafter, primary scanning direction). A print medium 4106 is inserted in the direction of an arrow mark through a sheet feeder opening 4101 provided in the front panel of the printing apparatus. As it is fed further, it is  
25 turned back and is delivered by a feeder roller 4109 to the printing area provided on a flat platen disposed directly below the liquid ejecting portion

4102. A carriage 4101 is movable in the direction  
predetermined by a pair of guide shafts 4104 and 4105  
arranged in parallel to the feeder roller 4109, and  
reciprocally scans the printing area, carrying the  
5 liquid ejecting portion 4102. As the liquid ejecting  
portion 4102, being carried by the carriage 4102,  
reciprocally scans the printing area, letters such as  
A, B and C illustrated in Figure 31 or other images  
reflecting the image data are printed on the  
10 predetermined area of the print medium 4106. A switch  
group and a display panel group 4107 are used to  
select various printing modes or display the status of  
the printing apparatus. An environment sensor 4103  
measures the internal temperature and humidity of the  
15 printing apparatus, using well-known means.

Figure 32 depicts the structure of the liquid  
ejecting portion 4102, wherein (a) is a perspective  
view of a plurality of subhead units in the liquid  
ejecting portion 4102 mounted on the carriage 4102;  
20 (b), a front view of the ejection portion as seen from  
the direction of the print medium, depicting the  
ejection outlet arrangement; and (c) is an enlarged  
sectional view of the liquid ejecting portion,  
depicting the internal structure of the ejection  
25 outlet illustrated in (b). Referring to 32(a) and  
32(b), the liquid ejecting portion 4102 comprises four  
subhead units which eject yellow ink Y, magenta ink M,

cyan ink C, or black ink Bk, and another subhead unit which ejects the P liquid. Each subhead unit in this embodiment generally comprises a head comprising the ejection outlet portion, which will be described

5 later, and a container portion for storing the ink.

Referring to Figure 32(a), the container 4011 - 4015 of the subhead units are composed of transparent material; therefore, the levels of the remaining ink and P liquid can be easily observed from outside.

10 Though the ink container in this embodiment is independently replaceable from each other, and also, from the head, it is acceptable to integrate the containers, for example, in a combination of the P liquid container and Bk ink container, a combination  
15 of Y, U and C ink container, or all of them.

Referring 32(b), the number of ejection outlets in each subhead unit in this embodiment is 128. They are aligned in the direction substantially perpendicular to the primary scanning direction,  
20 wherein the outlet pitch of each line is approximately 70  $\mu$ m. The outlet interval between the adjacent subhead units is 1/2 inch. This ejection portion 4102 can print with a resolution of 360 dpi by a single scanning pass.

25 Next, referring to Figure 32(c), the ejection outlet 4023 is connected to a common liquid chamber 4032 by way of an ink liquid path through which the

ink is supplied. Within the ink liquid path, a heat generating member 4030 and electrode wiring (unillustrated) are provided, wherein the former is an electrothermal transducer that generates thermal energy to be used for ejecting the ink supplied from the common liquid chamber 4032, and the latter supplies electrical power to the former. These heat generating member 4030 and electrical wiring are formed on a piece of substrate composed of silicon or the like, with the use of a film forming technology. On the heat generating member 4030, a protective film 4036 is formed so that the ink and heat generating member do not make direct contact. On the substrate 4033, resin or glass material is accumulated to form partitioning walls 4034 so as to create the aforementioned ejection outlets, ink path, common liquid chamber, and the like. In the liquid ejecting portion 4102 of this embodiment, the heat generating member 4030 is disposed so as to correspond with the ink ejecting outlet 4023, and is capable of ejecting the ink from the liquid ejecting outlet 4023, upon reception of the driving signal reflecting various printing data. Each heat generating member 4030 can independently generate the heat. When the ink within the nozzle is heated by the heat generating member 4030, it quickly reaches a state of film boiling, whereby bubbles are formed therein. As the bubbles

develop, the pressure is generated in the ink. As a result, the ink is ejected as an ink droplet toward the print medium 4106, forming thereon the letters or picture images as it lands.

5               From the Y, M, C and Bk ink ejecting outlets provided in the liquid ejecting portion 4102, an approximately 40 ng of the ink is ejected, and from the P liquid ejecting outlet, 30 - 40 ng of special ink is ejected.

10               In this embodiment, an electrothermal transducer element was used as the heat generating member in the liquid ejecting portion, but the present invention is not limited by this embodiment. For example, a piezo-electric element, which is an  
15               electromechanical transducer element, may be employed, or any ink ejecting means may be employed as long as it enables the ink jet printing apparatus to perform its function. The head structure illustrated in Figure 32(c) is of an edge shooter type, but, a side  
20               shooter type structure may be employed, which jets the ink or the like in the direction perpendicular to the surface of the heat generating member.

              Figure 33 is a table presenting a schematic of the data D1, which was derived from the image data,  
25               to be used for ejecting the print quality improver liquid. Figure 33(a) is a schematic of the data for the image to be printed. In this case, a yellow, red,



and black "I"s reflect the printing data. This letter  
"I" is formed by eight horizontal dots and 14 vertical  
dots. The image data are separated into sub-data for  
Y, M, C and Bk ink image, (b) presenting the data for  
5 yellow Y; (c), magenta M; (d), cyan C; and (e)  
presenting the data for black Bk. An alphabetic  
reference C stands for the data for not printing;  
therefore, there is no datum for C. Figure 33(f)  
presents the data D1 for printing the P liquid. The  
10 data D1 is a logical sum of the printing data for Y,  
M, C and Bk inks.

Figure 34 is a flow chart for an embodiment  
of the ink jet printing method in accordance with the  
present invention. This embodiment is characterized  
15 in that the amount of the print quality improver  
liquid is controlled in response to the internal  
temperature of the printing apparatus, wherein an  
alphabetic reference S in the flow chart stands for  
"step."

20 As the printing data are sent from the host  
computer to the printing apparatus, they are read into  
a receiving buffer within the printing apparatus  
(S101). Then, the internal temperature of the  
printing apparatus 4100 is measured by the environment  
25 sensor 4103 (S102). When the measured internal  
temperature is higher than a predetermined one, a  
control is executed to reduce the amount of the print

quality improver liquid to be deposited per unit area  
of the print medium. On the contrary, when it is  
lower than the predetermined one, a control is  
executed to increase the amount of the print quality  
5 improver liquid to be deposited per unit area of the  
print medium.

More specifically, when the temperature is  
high, a control is executed to reduce the energy to be  
given to the liquid ejecting heater (heat generating  
10 member) disposed adjacent to the liquid ejecting  
outlet of the head unit disposed in the liquid  
ejecting portion.

Figure 35 is a graph depicting the  
relationship between the internal temperature of the  
15 printing apparatus 4100 and  $T_w$ . As is evident from  
Figure 35, a rectangular pulse wave is applied to the  
liquid ejecting heater, which is an electrothermal  
transducer element constituted of resistive material,  
for a duration of  $T_w$  (= approximately 3  $\mu$ sec). When  
20 the temperature is 40°C, the  $T_w$  is set at 2.5  $\mu$ sec.  
On the contrary, when it is 5°C, which is rather low,  
the  $T_w$  is set at 4.0  $\mu$ sec. When it falls between the  
two temperatures, the  $T_w$  is linearly varied in  
response to the temperature.

25 Referring back to Figure 34, the printing  
data are converted into the data for Y, M, C and Bk  
inks (S103), and then, the P data are derived from the

Y, M, C and Bk data (S104). Next, the Y, M, C and Bk inks and P liquid are ejected from the corresponding subhead units in response to the Y, M, C, Bk, and P data (S105).

5 Embodiment 10

Figure 36 is a flow chart for another embodiment of the ink jet printing method in accordance with the present invention. This embodiment is characterized in that the amount of the  
10 P liquid to be ejected is controlled in response to the internal temperature and humidity of the printing apparatus. The compositions of the color inks and P liquid used in this embodiment are the same as those used in the preceding Embodiment 9.

15 As the printing data are sent from the host computer to the printing apparatus, they are read into a receiving buffer within the printing apparatus (S201). Then, the internal temperature of the printing apparatus 4100 is measured by the environment  
20 sensor 4103 (S202). When the measured internal temperature is higher than a predetermined one, a control is executed to reduce the amount of the print quality improver liquid to be deposited per unit area of the print medium. On the contrary, when it is  
25 lower than the predetermined one, a control is executed to increase the amount of the print quality improver liquid to be deposited per unit area of the

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print medium. Further, when the relative humidity HU is no more than 40% RH, the Tw is determined with reference to the graphic relationship (a) of Figure 37; when HU falls between 40% RH - 70% RH, it is  
5 determined with reference to the graphic relationship (b) of Figure 37; and when HU is no less than 70% RH, it is determined with reference to the graphic relationship (c) of Figure 37, wherein Figure 37 is a graph showing the relationship between the internal  
10 temperature of the printing apparatus 4100 and the Tw.

Referring back to Figure 36, the printing data are converted into the data for Y, M, C and Bk inks (S203), and then, the P data are derived from the Y, M, C and Bk data (S204). Next, the Y, M, C and Bk  
15 inks and P liquid are ejected from the corresponding subhead units in response to the Y, M, C, Bk, and P data (S205).

At this time, the compositions of the inks used in Embodiments 9 and 10 will be given below.

20 Y (yellow)

C.I. direct yellow 142 (dye)	2 parts
Thiodiglycol	10 parts
Acetylenol EH (Kawaken Fine Chemical)	0.05 part
Water	Rest

25 M (magenta)

The same as the Y ink, except that the dye is replaced with acid red 289 (2.50 parts)

C (cyan)

The same as the Y ink, except that the dye is replaced with C.I. acid blue 9 (2.50 parts).

Bk (black)

5           The same as the Y ink, except that the dye is replaced with C.I food black 2 (3.00 parts).

The composition of the P liquid is as follows.

Cationic compound of low molecular weight  
10       Stearyl trimethylammonium chloride   2.0 parts  
          (commercial name: Electro-stopper QE;  
          Kao Corp.)  
Cationic compound of high molecular weight  
Polyaminesulfon (average molecular  
15       weight: 5000)                           3.0 parts  
          (commercial name: PAP-92; Nitto Boseki  
          Co., Ltd.)  
Thioglycol                                   10 parts  
Water                                        rest

20           When the P liquid with the above composition and the color inks were caused to mix or react with each other on the print medium, the following preferable results were obtained.

Within the normal environment, it was  
25 possible to produce a "highly reliable" printed product, which displayed superior water and light resistances, and remained stable regardless of the

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temperature and humidity changes. Also, it was possible to produce an image of "high quality," in which no feathering occurred; density was high; and no color bleeding occurred when printed in color.

5 Embodiment 11

In the examples described in the preceding Embodiments 9 and 10, before the four color inks were ejected, the P liquid was deposited over the entire area where the color inks were to be deposited, and  
10 then, the color inks were ejected. This embodiment is characterized in that the P liquid is ejected onto only the area where the Bk ink is to be deposited.

Figure 38 is a simplified front view of an example of the ink ejecting portion employed in this  
15 embodiment of the ink jet printing method in accordance with the present invention. Printing is done using the liquid ejecting portion illustrated in Figure 38. As for the ejecting order, first, only the Y, M and C inks are ejected, being followed by the P  
20 liquid which is ejected onto the area where the Bk ink is going to be ejected, and then, the Bk ink is ejected thereon. According to such a method, the print quality can be improved at least in terms of the Bk ink: the reliability such as the water resistance  
25 or the like can be improved; the feathering can be prevented; and the density can be increased.

The printing method of this embodiment cannot

improve the reliability and print quality associated with the Y, M and C inks, but it can be effectively used when a user intends to produce a print product in which importance is placed on the Bk color as it is in  
5 the case of a print document spotted with few color images.

Embodiment 12

This embodiment is characterized in that printing is done using an ejecting portion, in which  
10 the subhead units are arranged as illustrated in Figure 39, is used; whereas in the preceding Embodiment 11, the liquid ejecting portion, in which the subhead units were arranged as illustrated in Figure 38, was used. Referring to Figure 39, the  
15 subhead units are arranged in the order of Y, M, C, B and P, relative to the direction of an arrow mark Q in the primary scanning direction.

Figure 40 is a flow chart of an operation in which the P liquid is applied to only the area onto  
20 which the Bk ink is to be ejected.

In a step S111, it is determined whether or not the printing data are for the Bk ink. When they are for the Bk ink, that is, when the answer is Yes, a step S112 is taken, and when NO, a step S113 is taken.

25 In the step S112, the P liquid is ejected before the Bk ink. At this time, the P liquid head is driven so that the P liquid position and Bk ink

position coincide on the print medium. It should be noted here that the high reliability and high quality can be obtained even when the P liquid is not ejected onto the entire locations onto which the Bk ink is ejected, that is, when the P liquid is ejected onto 25% of the locations onto which the Bk ink is ejected. Therefore, the data are thinned out in real time in step S112, and then, a step S113 is taken.

In the step S113, the normal single scanning pass printing operation is carried out. Namely, the head structure illustrated in Figure 39 is employed and the printing is done in the direction of an arrow mark R, in the order of Bk, C, M and Y.

The prescriptions for the inks and processing liquid used in this embodiment are as follows:

Y (yellow) ink

	Glycerine	5.0 wt.%
	Thioglycol	5.0 wt.%
	Urea	5.0 wt.%
20	Isopropyl alcohol	4.0 wt.%
	Acetylenol EH (Kawaken Chemical)	1.0 wt.%
	Dye C.I. direct yellow 142	2.0 wt.%
	Water	78.0 wt.%

M (magenta) ink

25	Glycerine	5.0 wt.%
	Thioglycol	5.0 wt.%
	Urea	5.0 wt.%



	Isopropyl alcohol	4.0 wt.%
	Acetylenol EH (Kawaken Chemical)	1.0 wt.%
	Dye C.I. acid red 289	2.5 wt.%
	Water	77.5 wt.%
5	<u>C (cyan) ink</u>	
	Glycerine	5.0 wt.%
	Thioglycol	5.0 wt.%
	Urea	5.0 wt.%
	Isopropyl alcohol	4.0 wt.%
10	Acetylenol EH (Kawaken Chemical)	1.0 wt.%
	Dye C.I. direct yellow 199	2.5 wt.%
	Water	77.5 wt.%
	<u>Bk (black) ink</u>	
	Glycerine	5.0 wt.%
15	Thioglycol	5.0 wt.%
	Urea	5.0 wt.%
	Isopropyl alcohol	4.0 wt.%
	Dye C.I. food black 2	23.0 wt.%
	Water	78.0 wt.%
20	<u>P liquid</u>	
	Polyallylamine hydrochloride	5.0 wt.%
	Benzalkonium chloride	1.0 wt.%
	Diethylene glycol	10.0 wt.%
	Acetylenol EH (Kawaken Chemical)	0.5 wt.%
25	Water	83.5 wt.%

As is evident from the above compositions,  
acetylenol EH, a surface activating agent, is added to

the Y, M, and C inks by 1.0% to improve the permeability, whereas it is not added to the Bk ink. Therefore, the Y, M and C inks are superior in the fixability to the Bk ink. On the other hand, the Bk  
5 ink is slightly inferior in the permeability to the Y, M and C inks, but it provides a higher density and a sharper edge; therefore, it is suitable for printing the letters or line drawings. Also, the acetylenol is added to the P liquid by 0.5% to improve slightly the  
10 permeability.

In this embodiment, the dye was used as the coloring materials for the Y, M, C and Bk inks, but the present invention is not limited by this embodiment. Namely, the coloring material may be  
15 pigment alone, a mixture of the dye and pigment, or the like, and as long as the proper P liquid, that is, a P liquid most suitable for aggregating any of the components in the ink composed of the coloring material and solvent, is used, the same effects can be  
20 obtained.

In this embodiment, an electrothermal transducer element was used as the heat generating member in the liquid ejecting portion, but the present invention is not limited by this embodiment. For  
25 example, a piezo-electric element, which is an electromechanical transducer element, may be employed, and also, there is no restriction concerning the

structure of the liquid ejecting portion.

Figure 41 is a plan view of a print produced using the printing method of this embodiment, that is, a result of the printing operation in this embodiment.

5 In this case, a title portion 4201, a main text portion 4202, and a picture image portion 4203 have been printed on a print medium 4106.

In this example of printed medium, the letters in the title portion '4201 are printed in R  
10 (red); the letters in the main text portion 4202 are printed in Bk (black); and the picture image in the picture image portion 4203 is printed in R. In terms of the overall layout of the print, the main text 4202 of the Bk occupies almost the entire page, and the  
15 rest of the page is spotted with the title and picture image portions in R.

The P liquid to be ejected ahead of the inks is ejected onto only the area correspondent to the main text portion which is to be printed in Bk; no P  
20 liquid is ejected onto the other areas. This is because it is in terms of only the Bk that a "highly reliable" print of "high quality" is wanted, in which the water resistance, light resistance, and the like are improved; the feathering and color bleeding are  
25 reduced; the color development is superior; and the print density is high.

For instance, if the entire surface of this

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print is splashed with water, the title and picture image portions are going to be washed out with the water, whereas the Bk portion is going to remain the same as before due to the effects of the P liquid, allowing thereby the contents to be read. In other words, in the case of a print composed mainly of the Bk, the objects of the print can be mostly fulfilled as long as the reliability and high quality are realized in the Bk portion.

10           The aforementioned process, in which the P liquid and ink are caused to mix and react with each other, has its own merits in that the high reliability and high quality are realized. On the other hands, the process also has demerits. That is, when the P liquid is ejected onto the entire surface of the print medium, or all the areas onto which the color inks are to be deposited, the P liquid is going to be wasted, which is one the causes of the running cost increase. Further, this process deposits an extra amount of liquid, that is, the P liquid, on the area where the color inks are to be deposited; in other words, the fiber of the print medium is given an additional amount of liquid. As a result, the print medium is cockled or wrinkled, which compromises the print quality. Even though the cockling may disappear after the print dries, the cockling occurring during the printing operation changes the predetermined

microscopic distance between the print medium and liquid ejecting portion, changing thereby the landing point of the ink droplet, which results in the deterioration of the print quality.

5           Only the P liquid is applied in correspondence with only the Bk, provided that the wanted print is going to be printed primarily by the Bk.

Embodiment 13

10           In Embodiment 12, the P liquid is sparingly applied depending on whether or not printing is done with the Bk. However, the present invention is not limited by this embodiment. For example, the P liquid may be spared depending on whether an image to be  
15   printed is a letters or a picture.

Figure 42 is a flow chart of a single scanning pass printing operation, in which the P liquid is ejected in correspondence with only a letter.

20           In a step S121, it is determined whether or not the printing data is for a letter. When they are for a letter, that is, when the answer is Yes, a step S122 is taken, and when it is No, a step S123 is taken. As for the means for determining whether or  
25   not the printing data is for a letter, it may be a known means.

In a step S122, the P liquid is ejected

before the printing is done in response to the letter printing data. At this time, the P head is driven in such a manner that the P liquid lands on the print medium, on the same spot on which a letter is printed.

5 It should be noted here that it is not necessary to eject the P liquid onto the entire spots onto which the letter producing ink is ejected; the high reliability and high quality can be obtained as long as the P liquid is ejected onto 25% - 50% of the spots  
10 onto which the letter producing ink is ejected. For example, when the color to be printed is a primary color Bk, Y, M or C, a ratio of 25% may selected, and when it is a secondary color R (red), G (green), or B (blue), another ratio of 50% may be selected. The  
15 process for thinning out the data for this operation is carried out in real time in a step S122, and then, a step S123 is followed.

In a step S123, a single pass printing operation is carried out in the normal primary  
20 scanning direction.

#### Embodiment 14

In Embodiment 12, the P liquid was sparingly used depending on whether or not printing is done with the Bk. However, the present invention is not limited  
25 by this embodiment. For example, the P liquid may be spared depending on whether an image to be printed is a Bk letters or not.

Figure 43 is a flow chart of a single scanning pass printing operation, in which the P liquid is ejected in correspondence with only a letter.

5           In a step S131, it is determined whether or not the printing data is for a letter. When they are for a letter, that is, when the answer is Yes, a step S132 is taken, and when it is No, a step S134 is taken. As for the means for determining whether or  
10 not the printing data is for a letter, it may be a known means.

          In the step S132, it is determined whether or not the printing data is for the Bk. When they are for the Bk, that is, when the answer is Yes, a step  
15 133 is taken, and when it is No, a step S134 is taken.

          In a step S133, the P liquid is ejected before the Bk letter is printed in response to the Bk letter printing data. At this time, the P head is driven in such a manner that the P liquid lands on the  
20 print medium, on the same spot on which a letter is printed. It should be noted here that it is not necessary to eject the P liquid onto the entire spots onto which the letter producing ink is ejected; the high reliability and high quality can be obtained as  
25 long as the P liquid is ejected onto 25% - 50% of the spots onto which the letter producing ink is ejected. The processing of thinning out the data for this

operation is carried out in real time in a step S133,  
and then, the step S134 is followed.

In the step S134, a single pass printing  
operation is carried out in the normal primary  
5 scanning direction.

Embodiment 15

In Embodiment 12, the P liquid is sparingly  
applied depending on whether or not printing is done  
with the Bk. However, the present invention is not  
10 limited by this embodiment.

When an inherently water resistant Bk ink  
replaces the aforementioned Bk ink, it may be used in  
combination with the Y, M and C inks, which normally  
do not have the water resistance, while ejecting the P  
15 liquid in correspondence with only the Y, M and C  
inks. This method can waterproof all the colors.

Figure 44 is a flow chart of a single pass  
printing operation, in which the P liquid is ejected  
in correspondence with only the C, M or Y inks.

20 In a step S141, it is determined whether or  
not the printing data is for the C, M or Y ink. When  
they are for the C, M or Y ink, that is, when the  
answer is Yes, a step S142 is taken, and when it is  
No, a step S143 is taken.

25 In the step S142, the P liquid is ejected  
before the C, M or Y ink is ejected in response to the  
corresponding printing data. At this time, the P head



is driven in such a manner that the P liquid lands on the print medium, on the same spot onto which the C, M or Y ink is ejected. It should be noted here that it is not necessary to eject the P liquid onto the entire spots onto which the C, M or Y ink is ejected; the high reliability and high quality can be obtained as long as the P liquid is ejected onto 25% - 50% of the spots onto which the C, M or Y ink is ejected. For example, when the color to be printed is a primary color Bk, Y, M or C, a ratio of 25% may selected, and when it is a secondary color R (red), G (green), or B (blue), another ratio of 50% may be selected. The process for thinning out the data for this operation is carried out in real time in the step S142, and then, a step S143 is followed.

In the step S143, a single pass printing operation is carried out in the normal primary scanning direction.

The Bk ink used in this embodiment is an ink produced through the following steps, and the water resistance is effected by this Bk ink.

Step 1: production of pigment dispersant

	Copolymer of styrene, acrylic acid, and ethyl acrylate (acid number: 140; weight average molecular weight: 5000)	1.5 wt.%
	Monoethanolamine	1.0 wt.%
	Diethyleneglycol	5.0 wt.%

Deionized water 82.5 wt.%

The above components are mixed, and heated to 70°C in a hot water bath to dissolve completely the resin components. Next, carbon black (MCF88, Mitsubishi Chemical) is added to this solution by 10 wt.%, and after 30 minutes of pre-mixing, the solution is subjected to the following dispersing process.

Dispersing apparatus:

Sand Grinder (Igarashi Machinery)

Grinding media:

zirconium beads (1 mm in diameter)

Grinding media filling ratio:

50 % (volumetric ratio)

Grinding time: three hours

Thereafter, coarse particles are removed through a step of centrifugal separation (12,000 rpm, 20 minutes), yielding the desired dispersion.

Step 2: production of ink

The dispersion obtained through the above steps is mixed with the following components, at a mixing ratio given below, yielding thereby the pigment containing Bk ink.

Pigment dispersed solution	30.0 wt.%
Glycerine	10.0 wt.%
Ethyleneglycol	5.0 wt.%
N-methylpyrrolidon	5.0 wt.%
Methyl alcohol	2.0 wt.%

Deionized water

48.0 wt.%

Embodiment 16

When the color inks are preferably water resistant, the P liquid does not need to be applied to the color ink locations. For example, when the Y ink is water resistant, it is unnecessary to apply the P liquid to the Y ink location. Further, the P liquid may be sparingly applied depending on the ink properties.

When the Bk and Y inks are water resistant; the M ink is fairly water resistant, though not completely; the C ink is an ordinary ink with no water resistance; and the print needs to be completely waterproofed in terms of all the colors, then, it is unnecessary to apply the P liquid to the Bk and Y ink locations, but it is necessary to apply the P liquid to the C and M ink locations, although the amount for the M ink location is smaller than the amount for the C ink location. In this manner, the print can be waterproofed for all the colors while using a minimum amount of the P liquid. The "smaller amount" relates to a smaller print duty or a smaller amount of the liquid to be ejected.

As described above, when the P liquid ejection is minimized in response to the properties of the ink to be used, it is possible to produce a "highly reliable" print of "high quality."

As for the structure of the liquid ejecting portion, it is not limited to the one illustrated in Figure 39. For example, the one illustrated in Figure 45 may be employed, in which the P head is disposed  
5 between the Bk head and the rest of the heads. Further, it may be a liquid ejecting portion having the structure illustrated in Figure 46, in which the liquid ejecting portion comprises three chips: a P liquid chip, a Bk chip, and an integral Y-M-C chip.

10 As for the effects of the P liquid, there are others besides the water resistance improvement. They are the light resistance improvement, feathering prevention, color bleeding prevention, color development improvement, print density improvement,  
15 and the like. Therefore, the P liquid may be selectively used to take advantage of these effects.

For example, when a Y ink to be used is excellent in the water resistance, but falls short in the feathering resistance, the feathering related  
20 characteristic of the print can be improved by means of selecting a printing method in which the P liquid is applied to the area onto which the Y ink is ejected.

When the P liquid is selectively used, as  
25 described above, depending on the objective of the print, it is possible to produce the highly reliable print of high quality.

Further, when the printing apparatus is provided with such a structure that a user can select whether or not the P liquid is to be applied, depending on the user's objective, a most preferable print can be produced as the user wishes. In this case, the user's selection may be indirectly inputted as the data of the host computer which transfers the data to the ink jet printing apparatus, or may be directly inputted through the sensor/SW portion thereof.

Embodiment 17

In the preceding Embodiments 9 - 16, only one kind of P liquid was used. In this embodiment, however, two or more P liquids of different type are used, which characterizes this embodiment.

Figure 47 is a simplified front view of a liquid ejecting portion capable of ejecting two or more print quality improver liquid of different type, which is used in conjunction with the ink jet printing method in accordance with the present invention. As shown in Figure 47, the liquid ejecting portion of this embodiment is provided with a P liquid ejecting subhead units P1 and P2. In this embodiment, when the temperature is high, the P1 liquid is ejected using the liquid ejecting outlet P1, and otherwise, the P2 liquid is ejected using the subhead unit P2.

(P1 liquid)

	Polyallylamine hydrochloride	1.0 wt.%
	Tributylamine chloride	1.0 wt.%
	Thioglycol	10.0 wt.%
	Acetylenol EH	0.3 wt.%
5	Water	87.7 wt.%
	(P2 liquid)	
	Polyallylamine hydrochloride	1.0 wt.%
	Tributylamine chloride	1.0 wt.%
	Thioglycol	10.0 wt.%
10	Acetylenol EH	0.7 wt.%
	Water	87.3 wt.%

When the temperature and/or humidity is detected, and the detected results are used to switch between the differently composed P1 and P2 liquids, or to eject both liquids while controlling the amount of the P1 or P2 liquid to be ejected, preferable effects can be produced.

#### Embodiment 18

In the preceding Embodiments 9 - 16, the P liquid control executed in a situation, in which all the sheets of print medium were of the same type, was described. In this embodiment, the amount of the P liquid to be ejected is optimally adjusted according to the type of the print medium, that is, according to whether the print medium is plain paper, transparency for the OHP, or something else, so that the most reliable image of the highest quality can be produced

in terms of the print medium.

More specifically, whether the print medium is plain paper, transparency for the OHP, or something else is automatically determined using a known means, for example, a combination of mechanical and optical sensors, or the like. When the print medium is the latter, the amount of the P liquid to be ejected per unit area of the print medium is reduced in comparison with when it is the former. This is because the printing surface of the transparency for the ink jet printing is generally provided with an ink receptive layer, which allows a less amount of the ink to permeate into the print medium than the plain paper, and therefore, the P liquid and color ink more stably mix or react with each other than when the plain paper is used.

Further, different types of P liquid may be used depending on whether the print medium is plain paper or transparency for the OHP. More specifically, the P1 and P2 liquids used in Embodiment 17 are used as the print quality improver liquid for the transparency sheet, and plain paper, respectively.

Further, when more than two types of print medium are used, a corresponding number of different P liquids may be selectively used. In this case, however, when the number of the available different P liquids is less than the number of the different print

mediums, the effects may be optimized by means of controlling the amount of the pertaining P liquid to be ejected.

When the amount and/or type of the P liquid  
5 is optimally selected according to the type of print medium, as described above, the most reliable image of the highest quality can be produced in terms of the print medium.

In addition, when the amount and/or the type  
10 of the P liquid to be used is optimally selected according to the type of print medium, and environmental factors such as the internal temperature or humidity of the printing apparatus, idealistic results can be expected.

15 Figure 48 is a block diagram of an ink jet printing apparatus in which the printing methods described in the preceding embodiments can be practiced. The data for the letters and picture images to be printed (hereinafter, image data) are  
20 inputted from a host computer to the receiving buffer 4401 of the printing apparatus, whereas the data for confirming whether or not the image data are correctly transferred, and the data for notifying the  
operational state of the printing apparatus, are sent  
25 from the printing apparatus to the host computer. The data in the receiving buffer 4401 are transferred, under the control of a CPU 4402, to a memory portion



4403, where they are temporary stored in an RAM  
(random access memory). A mechanism controlling  
section 4404 drives mechanism 4402 such as a carriage  
motor, a line feeder motor, or the like, in response  
5 to the commands from the CPU 4402. A sensor/SW  
controlling section 4406 sends to the CPU 4402, the  
signals generated in the sensor/SW section comprising  
various sensors and SWs (switches). A display element  
controlling section 4408 controls a display element  
10 section 4411 comprising LEDs, liquid crystal display  
elements, and the like in a group of display panels,  
in response to the commands from the CPU 4402. An  
liquid ejecting section controlling section 4410  
controls the liquid ejecting section 4411 in response  
15 to the commands from the CPU 4402. It also collects  
the temperature data and the like, which reflects the  
condition of the liquid ejecting section 4411, and  
sends them to the CPU 4402.

The P liquid in accordance with the present  
20 invention includes colorless liquid capable of  
insolubilizing the ink dye, as well as liquid capable  
of aggregating the ink pigment by means of disturbing  
the pigment dispersion equilibrium. Here,  
insolubilization means such a phenomenon that the  
25 anionic radicals contained in the dye in the ink, and  
the cationic radicals of the cationic components  
contained in the print quality improver liquid, react

with each other, being ionically combined, and as a result, the dye having been uniformly dissolved in the ink separates from the ink solution. It should be not here that according to the present invention, such effects as the color bleeding prevention, improvement in color development, improvement in letter quality, or improvement in fixibility of the ink can be realized even when not all the dye in the ink is insolubilized. Further, in the description of the present invention, a terminology, "aggregation," is used as a word having the same meaning as "insolubilization." When the coloring material used in the ink is pigment, the insolubilization also means such a phenomenon that the pigment dispersant or pigment surface, and the cationic radicals of the cationic substance contained in the print quality improver liquid, ionically react with each other, disturbing the dispersive equilibrium, and as a result, the diameter of the pigment particle increases. Normally, the ink viscosity increases as the aggregation progresses. It should be noted here that according to the present invention, even when not all of the pigment or pigment dispersant in the ink is insolubilized, the effects such as the color bleeding prevention and improvements in color development, letter quality, and fixibility of the ink, which have been described in this specification, can be realized.

As is evident from the above description, according to the present invention, the reliability of the print product, such as the water resistance or the like, can be improved by means of causing the print  
5 quality improver liquid and color ink to mix and react with each other on the print medium. Also, the same means can improve the color development, and prevent the feathering, color bleeding, and the like; therefore, the print quality can be improved.

10 Further, according to the present invention, a reliable print of high quality can be stably produced under all the environmental conditions, except for extreme cases, in terms of the normal usage of the printing apparatus.

15 Further, the print medium is optimally treated according to the print medium type, that is, according to whether it is a transparency sheet for the OHP, or something else; therefore, a print with the highest degree of reliability and quality can be  
20 obtained in terms of the print medium.

Further, the P liquid is selectively used depending on the objective of the print product to be obtained; therefore, a highly reliable print of high quality can be obtained with a minimum consumption of  
25 the print quality improver liquid. In addition, the minimum consumption of the print quality improver liquid reduces the running cost, and minimizes the

cockling of the print medium, improving further the print quality.

Hereinafter, Embodiment 19, which is in the fourth form of the present invention, will be  
5 described with reference to Figures 49 - 55.

The following descriptions include cases in which the liquid ejecting portion is a part of a single printing head unit, and in which it constitutes a separate subhead unit, being independent from the  
10 rest.

Embodiment 19

Figure 49 is a perspective view of an ink jet recording apparatus to which the present invention is applicable. After being inserted into the feeding  
15 point of a recording apparatus 5100, a recording medium 5106 is advanced by a feeding roller 5109, in the direction of an arrow mark P, to an area in which a recording head unit 5103 can record images on the recording medium 5106. There is a platen 5108 under  
20 the recording medium in the recording area. The carriage 5101 is supported on two guide shafts 5104 and 5105, being allowed to move in a predetermined direction, and shuttles across the recording area, scanning the recording medium. Mounted on the  
25 carriage 5101 are a recording head for ejecting a plurality of color inks and processing liquids (print quality improver liquid), and a recording head unit

5103 containing the ink containers which supply the ink or processing liquid to the recording head. The number of the inks used in this ink jet recording apparatus is four, and their colors are Bk (black), C (cyan), M (magenta), and Y (yellow).

There is a recovery system unit 5110 next to, and below, the left edge of the moving area of the carriage 5101. It performs the recovery operation when the ejection of the ink and recording quality improver liquid (processing liquid S) becomes erratic, and caps the liquid ejecting outlet portion of the recording head during a non-recording period. This left end position is called the home position of the recording head.

A reference numeral 5107 designates both of a switch portion and a display element portion. The switch portion is used to turn on or off the power supply of the recording apparatus, and also, to set various recording modes. The display element portion plays a role of displaying the operational state of the recording apparatus.

Figure 50 is a perspective view of a recording head unit 5103. In this embodiment, the Bk, C, M and Y ink containers for supplying the recording head 5102 with the inks, and the recording quality improver liquid S container, are all replaceable, independently from each other.

On the carriage 5101, the recording head 5102 which ejects Bk, C, M and Y inks and S liquid, a Bk ink container 5012, a C ink container 5013, an M ink container 5014, a Y ink container 5015, and an S liquid container 5011, are mounted. Each container is connected to the recording head by way of a connecting portion, and supplies the recording head with the ink or processing liquid. The ink containers are composed of transparent material so that the levels of the liquid remaining therein can be seen.

Further, the recording quality improver liquid container and Bk ink container may be integrated into a single pieces, and the C, M and Y ink containers may be integrated into a single piece. Also, all the contains may be integrated into a single piece.

Figure 51 is a schematic drawing to show the arrangement of the liquid ejecting outlets of the recording head 5102, as seen from above, through the recording medium 5106. The recording head 5102 moves in the direction of an arrow mark Q, relative to the recording medium 5106; the recording medium 5106 moves in the direction of an arrow mark P, relative to the recording head. The numbers of the liquid ejecting outlets of the S head and Bk head are 128 for both. The number of the ink ejecting outlets of the Y, M or C portion of the integrated Y-M-C head, is 48 for each

portion. The lengths of the separating zones between Y and M, and between M and C, are equivalent to eight ejection outlets.

The pitch of the ejection outlet is approximately 70  $\mu\text{m}$  for the S, Bk, and C-M-Y portions. The distance between the S and Bk portions, or between the Bk and Y-M-C portions, is equivalent to 180 ejection outlets. The liquid ejecting outlets of each of the liquid ejecting subhead portions are arranged in a single straight line substantially perpendicular to the primary scanning direction. The bottom ends of the S, Bk, and Y-M-C subhead portions are aligned in the primary scanning direction of the recording head 5102.

A block diagram of the essential structure of the printer in this embodiment is the same as the one given in Figure 48.

Figure 52 is a flow chart for the recording operation in this embodiment.

A step S301 is a recording mode determining step, where a recording mode is set using recording mode determining means. In this embodiment, one of three recording modes a, b and c is selected. As for the method for setting the mode, there are two. One is to set it automatically according to the data sent from the host computer, and the other is to input using the SW portion of the recording apparatus. In

this embodiment, the former was employed, but either method is acceptable.

A step S302 is a step to be taken when the recording mode a is selected, and in this step, a recording operation equivalent to a single page is carried out. This recording mode a is a mode in which the recording quality improver liquid S is ejected in correspondence with the entire image to be recorded, wherein the S liquid and the inks are caused to mix and react to each other on the recording medium, improving the water resistance and color development of the recorded image, minimizing the color bleeding, and improving the fixability of the ink to the recording medium. In other words, this mode a is such a recording mode that consumes a maximum amount of the recording quality improver liquid S, and maximizes its effects.

In comparison to the recording mode c, the recording mode a increases the amount of the Y, M, C, or Bk ink ejected per unit area of the recording medium. More specifically, the wave-form of the head driving power is controlled so as to increase the ink droplet size to approximately 1.05 time the ink droplet size in the recording mode c. This controlling method is a known method of modulating the pulse width, but the ink droplet size may be increased by means of increasing the head temperature. In other



words, it does not matter what means is used. As for  
the ratio of the increase, it is designed so that an  
optimum value is selected according to the ink,  
recording quality improver liquid, recording medium,  
5 and the like. This means is provided in the recording  
head controlling section.

When this process is not carried out,  
deterioration of the recorded image occurs in the area  
where the recording quality improver liquid S and ink  
10 mix and react with each other. For example, the image  
looks grainy, and the color of the recording medium  
(normally, white) becomes obtrusive.

The reason why the amount of the ink to be  
ejected per unit area is increased is because the  
15 increase slightly reduces the ink dot diameter as the  
recording quality improver liquid S and ink mix and  
react with each other on the recording medium.

This process can be further improved when it  
is modified so that only the volume of the ink droplet  
20 that is ejected onto an exactly the same spot as the  
recording image improver liquid S is increased,  
whereas the volume of the ink droplet that is not  
ejected onto the same spot as the recording quality  
improver liquid is not increased.

25 This process is also effective in the second  
recording mode b because of the same reason.

A step S303 is a step to be taken when the

recording mode b is selected, in which a recording operation equivalent to a single page is carried out. This is a recording mode in which the recording quality improver liquid S is ejected onto the borders among the different colors of the recorded image, in particular, the borders between the black and the other colors Y, M and C. In other words, it is a recording mode for obtaining a picture image in which the color bleeding is prevented, in particular, the color bleeding between the black color and the other colors Y, M and C. This process has its own merits in the minimization of the recording quality improver liquid S to be ejected onto the recording medium. The borders between the Bk and the others Y, M and C are detected using a known means.

In this embodiment, the process in which the recording quality improver liquid S is ejected onto the borders between the Bk and others Y, M or C was employed, but another process in which it is ejected onto all the borders between each of Bk, Y, M, and C may be employed.

A step S304 is a step to be taken when the recording mode c is selected, in which a recording operation equivalent to a single page is carried out. This is a recording mode in which the recording quality improver liquid S is not ejected, that is, a mode in which recording is made in the same manner as

the conventional one. This mode also has its own merits in that since the recording quality improver liquid S is not used so as to realize recording quality of only the conventional level, the running  
5 cost does not increase.

As described above, the recording mode is selected for each page as needed.

In the recording mode b, the recording quality improver liquid S is ejected from the nozzles  
10 allocated so as to move ahead of the nozzles allocated for ejecting the Bk ink during each of the forward and backward scanning movements; therefore, the bidirectional recording is possible.

According to this recording structure, the  
15 liquid ejecting portions are arranged in the order of S, Bk, and Y-M-C, relative to the primary scanning direction X1. During a normal recording operation, the borders between the Bk and the others Y, M and C are detected on the recording area, and the S is  
20 ejected ahead of the Bk. Immediately, the Bk and S react with each other, and as a result, the state of the Bk changes so that it is difficult for the Bk to bleed into the Y, M or C from the borders between the Bk and the others Y, M or C. Thereafter, the Y, M and  
25 C are ejected. Therefore, the color bleeding between the Bk and other Y, M or C is unlikely to occur.

On the contrary, the order in the X2

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direction is Y-M-C, Bk, and S. In this direction X2, the Y, M and C are first ejected, being followed by the Bk, and lastly, the S is ejected. Since the S is ejected after the Y, M, C and Bk bleed on the recording medium, this structure is not effective to prevent the bleeding, when scanning in the X2 direction. As a countermeasure, it is conceivable to use a unidirectional recording in the X1 direction, but such a recording method reduces the recording speed.

Therefore, in this mode b, in order to prevent the bleeding using the single pass bidirectional printing method, the use is made with the nozzles so as to allow the recording quality improver liquid S to be ejected ahead of the Bk in the recording area, in either direction.

Figure 53 illustrated the outlet allocation for each ink and S liquid employed in the recording mode b. In the Y-M-C portion, all the outlets are activated. In the S liquid portion, 48 outlets in the R1 section, which correspond to the C portion in the primary scanning direction, are activated, and in the Bk portion, 48 outlets in the R2 section, which correspond to the M portion in the primary scanning direction, are activated.

In the X1 direction, recording is made in the order of S, C, Bk, M and Y; in the X2 direction, in

the order of C, S, M, Bk and Y. In the case of the  
bidirectional recording, the recording is made in the  
order of S, C, M, Bk and Y. More specifically, there  
are R4 and R5 sections with no outlets; therefore, the  
5 order remains as such that the Bk is ejected after S  
and C are ejected. In other words, it is assured that  
the Bk is ejected after the S is ejected. Therefore,  
the bleeding of the Bk into the other colors is  
minimized due to the effects of the S liquid, while  
10 allowing the single pass high speed bidirectional  
printing.

As for the compositions of the inks and  
processing liquid used in this embodiment, they are  
the same as those used in Embodiment 12.

15 Figure 54 illustrates an example of an liquid  
ejecting portion employing electromechanical  
transducer elements, wherein a reference numeral 5038  
designates a piezo-electric element, which is the  
electro-mechanical transducer element.

20 The other portions of the structure are not  
essential to the following description.

In the preceding embodiments, the recording  
mode was switched page by page, but the present  
invention is not limited by those embodiments.

25 For example, when switching is made among the  
recording modes a, b and c within the same page, the  
following effects can be realized, provided that the

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recording modes a, b and c are the same as those of the preceding embodiment.

As for the print to be made, let it be that the major portion (part 1) of the print is occupied with black letters; a small portion (part 2) is occupied with a picture image, that is, a landscape in color; and another small portion (part 3) is filled with a color graph.

In this case, preferable effects can be obtained by means of printing the part 1 in the recording mode c; the part 2, in the recording mode a; and the part 3, in the recording mode b.

Since the part 1 is occupied with only the black letters, there is no contact between the Bk and others Y, M and C, on the recording medium, eliminating thereby the bleeding between the Bk and others Y, M and C. Therefore, the S is not used; the S is saved.

The image which is going to occupy the part P is a landscape. Therefore, the S is applied to all the locations onto which the inks are ejected, in order to maximize the color development.

The part 3 is going to be occupied with a graph, in which each of the colored portions is desired to be clearly edged. Therefore, the S is applied to only the edge portions among the colors, so that the color bleeding can be minimized while saving

the S by not applying it to the entire recording area.

As described above, when the S is applied in response to the automatic determination of the recording mode having been set so as to match  
5 individual recording areas, the consumption of the S can be minimized while maximizing its effects in order to print a preferable image.

Figure 55 is a flow chart for recording a single page, in which the different recording modes  
10 are automatically determined within the same page.

A step S311 is a step in which the characteristic of the image to be recorded is determined, at the level of picture element. In this case, it is determined whether the image to be printed  
15 is a text, a graph or a picture image. It is determined using a known means, and a certain degree of determination error must be tolerated depending on the selected means. In the case of the text, a step S312 is taken; in the case of the graph, a step S313;  
20 and in the case of the picture image, a step S314 is taken.

The step S312 is a step to be taken in the case of the text, in which a process equivalent to the mode c is carried out. Namely, the normal printing  
25 operation, in which the S is not used, is carried out.

The step S313 is a step for a graph, in which a process equivalent to the mode b is carried out.

Namely, data for ejecting the S to only the border portions among the Y, M, C and Bk colors are produced.

The step S314 is a step to be taken when the image is going to be a graph, in which a process  
5 equivalent to the mode a is carried out. Namely, the S data for applying the S over the entire recording area are produced.

A step S315 is a step in which an actual recording operation is carried out, ejecting  
10 sequentially the Y, M, C, Bk and S in correspondence with the recording data.

In this embodiment, it was determined whether the image to be recorded was a letter, a graph, or a picture image, but the image characteristics may be  
15 optimally classified into an optional number of categories as needed. For example, the recording mode c may be used for only a letter while using the recording mode a for a graph or picture image.

The following means was not described in  
20 detail in the preceding embodiments of the present invention, but it may be considered as a modification of the present invention. Namely, when the recording quality improver liquid is of a special type that does not cause the pigment aggregation, or does not  
25 insolubilize the dye, in the inks of a predetermined type, but does so in the inks of different type, it may be mixed in the inks of the aforementioned



predetermined type. Needless to say, this recording  
quality improver liquid is ejected and coated together  
with the ink. The only requirement for the recording  
quality improver liquid of this type is to contains  
5 components capable of improving at least the recording  
quality, and needless to say, it may contain, in  
addition to such mandatory components, different  
components capable of improving the other properties.

In the case of the structures in accordance  
10 with the present invention, the ink is introduced into  
an ink container through an ink introduction path  
established by means of connecting an ink supplying  
pipe or the like to the ink container. As for the  
location of the connection, the ink supplying pipe or  
15 the like may be connected to the ink supplying port  
through which the ink is supplied to an ink jet  
recording head; an air vent; or a hole drilled  
adjacent to the wall surface of the ink container.

According to the present invention, the  
20 recording quality improver liquid is stored in a part  
of the container portion; therefore, when an apparatus  
user replaces an ink depleted ink container due to the  
depletion of a coloring material containing ink, the  
recording quality improver liquid may be replenished  
25 at the same time. Therefore, it is preferable that  
when the ink is injected into an ink container as  
described above, the recording quality improver liquid

is also injected at the same time. It is needless to say that the recording quality improver liquid can be injected using the same means and procedure as the inks.

5           As has been described above, according to the present invention, it is possible to use selectively two or more of the following recording modes for each page as needed.

10           Recording mode a: the S and inks are caused to mix and react with each other to improve the water resistance and color development of a recorded image, to minimize the color bleeding among two or more colors, and also, to improve the fixability of the ink to the recording medium;

15           Recording mode b: the S is ejected onto the locations which are going to constitute the borders among the colored areas of the recorded image, in particular, the borders between the Bk and others Y, M and C, to prevent the color bleeding while saving the  
20 S.

          Recording mode c: S is not ejected; printing is made in the conventional manner.

          Further, it is possible to increase the volume of the ink droplet to be ejected onto the same  
25 location onto which the S is ejected to mix with the ink; therefore, recording can be made with no change in dot diameter whichever recording mode is used, a,

b, or c.

The present invention brings forth preferable results when used in conjunction with the ink jet printing system, in particular, when used with such an ink jet printing head, or a printing apparatus, that comprises a means (for example, an electrothermal transducer, a laser, or the like) for generating thermal energy to be used for changing the phase of the ink so as to eject the ink. This is because such a system can produce a highly precise image of high density.

The typical structure and the operational principle are preferably the ones disclosed in U.S. Patent Nos. 4,723,129 and 4,740,796. The principle and structure are applicable to a so-called on-demand type recording system and a continuous type recording system. Particularly, however, it is suitable for the on-demand type because the principle is such that at least one driving signal is applied to an electrothermal transducer disposed on a liquid (ink) retaining sheet or liquid passage, the driving signal being enough to provide such a quick temperature rise beyond a departure from nucleation boiling point, by which the thermal energy is provided by the electrothermal transducer to produce film boiling on the heating portion of the recording head, whereby a bubble can be formed in the liquid (ink) corresponding

to each of the driving signals.

By the production, development and contraction of the bubble, the liquid (ink) is ejected through an ejection outlet to produce at least one  
5 droplet. The driving signal is preferably in the form of a pulse, because the development and contraction of the bubble can be effected instantaneously, and therefore, the liquid (ink) is ejected with quick response. The driving signal in the form of the pulse  
10 is preferably such as disclosed in U.S. Patents Nos. 4,463,359 and 4,345,262. In addition, the temperature increasing rate of the heating surface is preferably such as disclosed in U.S. Patent No. 4,313,124.

The structure of the recording head may be as  
15 shown in U.S. Patent Nos. 4,558,333 and 4,459,600 wherein the heating portion is disposed at a bent portion, as well as the structure of the combination of the ejection outlet, liquid passage and the electrothermal transducer as disclosed in the above-  
20 mentioned patents. In addition, the present invention is applicable to the structure disclosed in Japanese Laid-Open Patent Application No. 123670/1984 wherein a common slit is used as the ejection outlet for plural electrothermal transducers, and to the structure  
25 disclosed in Japanese Laid-Open Patent Application No. 138461/1984 wherein an opening for absorbing pressure wave of the thermal energy is formed corresponding to

the ejecting portion. This is because the present invention is effective to perform the recording operation with certainty and at high efficiency irrespective of the type of the recording head.

5           The present invention is effectively applicable to a so-called full-line type recording head having a length corresponding to the maximum recording width. Such a recording head may comprise a single recording head and plural recording head  
10 combined to cover the maximum width.

          In addition, the present invention is applicable to a serial type recording head wherein the recording head is fixed on the main assembly, to a replaceable chip type recording head which is  
15 connected electrically with the main apparatus and can be supplied with the ink when it is mounted in the main assembly, or to a cartridge type recording head having an integral ink container.

          The provisions of the recovery means and/or  
20 the auxiliary means for the preliminary operation are preferable, because they can further stabilize the effects of the present invention. As for such means, there are capping means for the recording head, cleaning means therefor, pressing or sucking means,  
25 preliminary heating means which may be the electrothermal transducer, an additional heating element or a combination thereof. Also, means for

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effecting preliminary ejection (not for the recording operation) can stabilize the recording operation.

As regards the variation of the recording head mountable, it may be a single corresponding to a single color ink, or may be plural corresponding to the plurality of ink materials having different recording color or density. The present invention is effectively applicable to an apparatus having at least one of a monochromatic mode mainly with black, a multi-color mode with different color ink materials and/or a full-color mode using the mixture of the colors, which may be an integrally formed recording unit or a combination of plural recording heads.

Furthermore, in the foregoing embodiment, the ink has been liquid. It may be, however, an ink material which is solidified below the room temperature but liquefied at the room temperature. Since the ink is controlled within the temperature not lower than 30°C and not higher than 70°C to stabilize the viscosity of the ink to provide the stabilized ejection in usual recording apparatus of this type, the ink may be such that it is liquid within the temperature range when the recording signal is applied. Further, the present invention is applicable to other types of ink. In one of them, the temperature rise due to the thermal energy is positively prevented by consuming it for the state

change of the ink from the solid state to the liquid state. Another ink material is solidified when it is left, to prevent the evaporation of the ink. In either of the cases, upon the application of the recording signal producing thermal energy, the ink is liquefied, and the liquefied ink may be ejected. Another ink material may start to be solidified at the time when it reaches the recording material. The present invention is also applicable to such an ink material as is liquefied by the application of the thermal energy. Such an ink material may be retained as a liquid or solid material in through holes or recesses formed in a porous sheet as disclosed in Japanese Laid-Open Patent Application No. 56847/1979 and Japanese Laid-Open Patent Application No. 71260/1985. The sheet is faced to the electrothermal transducers. The most effective one for the ink materials described above is the film boiling system.

The ink jet recording apparatus may be used as an output terminal of an information processing apparatus such as computer or the like, as a copying apparatus combined with an image reader or the like, or as a facsimile machine having information sending and receiving functions.

Figure 15 is a block diagram of the general structure of an information processing apparatus, such as a word processor, a personal computer, a facsimile,

or a copying machine, which comprises a printing apparatus in accordance with the present invention.

In the drawing, a reference numeral 1801 designates a control section, which comprises a CPU  
5 such as a microprocessor, and various I/O ports, and controls the entire apparatus, outputting or receiving control signals, data signals and the like, to or from various sections of the apparatus. A reference numeral 1802 designates a display section, which  
10 displays various menus, text information, image data read in through an image reader, and the like, on its display screen. A reference numeral 1803 designates a transparent, pressure sensitive touch panel located on the display panel section 1802, the surface of which  
15 can be touched with a finger or the like to select the items displayed in the display section 1802. The touch panel may be of a coordinate based type.

A reference numeral 1804 designates an FM (Frequency Modulation) sound source section, which  
20 stores musical data produced by a music editor or the like, in a memory section 1810 or an external memory device 1812, as digital data, and reads them out of the memory or the like, modulating them in frequency. The electrical signal from the FM sound source section  
25 is converted into an audible sound through a speaker section 1805. A printer section 1806 is the output terminal of a word processor, a personal computer, a



facsimile, or a copying machine, in which a printing apparatus in accordance with the present invention is employed.

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5 A reference numeral 1807 designates an image reader section which photoelectronically reads in the data of an original, and is disposed at a location in an original circulating path. It reads various originals such as a facsimile original or a copy original. A reference numeral 1808 designates a  
10 transmission-reception section of a facsimile (FAX), which transmits the original data read in through the image reader section, or receives the arriving facsimile signal and decode it; in other words, it has a function to interface with external signal sources.  
15 A reference numeral 1809 designates a telephone section which has various functions such as an ordinary telephone function, an answering machine function, and the like.

20 A reference numeral 1810 designates a memory section, which comprises an ROM and an RAM, and stores system programs, manager programs, various application programs, fonts, dictionaries, text information or application programs loaded from the external memory device 1812, video data, and so on.

25 A reference numeral 1811 designates a key board section for inputting text data, various commands, and the like.

A reference numeral 1812 designates an external memory device employing a floppy disk or a hard disk, and the like, as recording medium. It stores text data, music or voice data, user's application programs, and the like.

Figure 16 is a schematic external view of the information processing apparatus depicted in Figure 15.

In the drawing, a reference numeral 1901 designates a flat panel display constituted of liquid crystal or the like. It displays various menus, text data, and the like. The surface of this display 1901 constitutes a touch panel 1803 of pressure sensitive type or coordinate based type, which a user can press or touch, on the location where the wanted selection is. A reference numeral 1902 designates a hand set to be used when the apparatus is used as a telephone. A key board 1903 is removably connected to the main assembly of the apparatus, with a cord. It is used to input various text data and others, and is provided with various function keys. A reference numeral 1905 designates an opening through which a floppy disk is inserted into the external memory device 1812.

A reference numeral 1906 designates a sheet mounting table section for mounting an original to be read by the image reader section 1807, and the read original is discharged from the rear of the apparatus.

When the facsimile signal or the like is received, the image reflecting the signal is outputted as a print by an ink jet printer 1907.

Although the aforementioned display section  
5 1802 may be constituted of a CRT, a flat panel such as a liquid crystal display constituted of highly dielectric liquid crystal is preferable. This is because the use of the latter makes it possible to reduce the size and weight of the apparatus.

10 When the aforementioned information processing apparatus is functioning as a personal computer or a word processor, various data inputted through the key board section 211 are process by the control section 1801, and are outputted to the printer  
15 section 1806.

When it is functioning as a receiving facsimile, the facsimile data, which are transmitted through a communication line and inputted through the FAX receiving section 1808, are processed by the  
20 control section 1801 according to a predetermined program, and outputted, as the image data, to the printer section 1806.

When it is functioning as a copying machine, an original is read in by the image reader section  
25 1807, and the data read in from the original are outputted, as the image data, to the printer section 1806 by way of the control section 1801.

When it is functioning as a transmitting facsimile, the data read in from an original by the image reader section 1807 are processed for transmission, by the control section 1801, according to a predetermined program, and then, are transmitted onto a communication line, by way of the FAX transmitter section 1808.

The aforementioned information processing apparatus may be of a type comprising integrally an ink jet printer as illustrated in Figure 17; the integration makes the apparatus more easily portable. In the same drawing, the sections having the same function as those in Figure 16 are designated with corresponding reference numerals.

When a printing apparatus in accordance with the present invention is employed in the multi-functional information processing apparatus described above, a high quality print image can be produced at a high speed with a low noise; namely, the functions of the aforementioned information processing apparatus can be further improved.

While the invention has been described with reference to the structures disclosed herein, it is not confined to the details set forth and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.